This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

GODFREY LOWELL CABOT SCIENCE LIBRARY
of the Harvard College Library

This book is
FRAGILE
and circulates only with permission.
Please handle with care
and consult a staff member
before photocopying.

Thanks for your help in preserving
Harvard's library collections.

Eng 1010.5

55th Congress, 2d Session. | HOUSE OF REPRESENTATIVES. | Document No. 2.

ANNUAL REPORTS

OF THE

WAR DEPARTMENT

Mississippi River Com

FOR THE

FISCAL YEAR ENDED JUNE 30, 1897.

REPORT OF THE

CHIEF OF ENGINEERS.

PART 5.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1897.

Eng 1010.5

919 44/6

HARVARD COLLEGE LIBRARY
FEB 16 1901
CAMBRIDGE, MASS.

Charles Moore
Wash. D.C.

CONTENTS.

[Alphabetical index will be found at the end of each part, or volume.]

PART I.

OFFICERS OF THE CORPS OF ENGINEERS.

Status, changes, and distribution of officers of corps, 3.

THE BOARD OF ENGINEERS........................ 4

POST OF WILLETS POINT, NEW YORK.—U. S. ENGINEER SCHOOL.—BATTALION OF ENGINEERS.—ENGINEER DEPOT.

Officer in command, Maj. John G. D. Knight, Corps of Engineers—

Post of Willets Point, 4; U. S. Engineer School, 5; Battalion of Engineers, Engineer Depot, 6; statement of funds, 7; estimates, 22.

FORTIFICATIONS.

Projects, sites, 7; sea walls and embankments, preservation and repair of fortifications, new works, appropriations, 8; emplacements, continuing contacts, 9, 10; submarine mines, defenses of coasts of Maine and New Hampshire, 11; Boston, Mass., southeast coast of Massachusetts and Rhode Island, 12; eastern entrance to Long Island Sound at New York, N. Y.—eastern entrance to harbor, on islands in harbor, 13; on Staten Island, southern entrance to New York Harbor, on Long Island and Sandy Hook, Delaware River, 14; Baltimore, Md., Washington, D. C., 15; Hampton Roads, Va., coast of North Carolina, coast of South Carolina, 16; coast of Georgia and Cumberland Sound, coast of Florida, 17; Pensacola, Fla., Mobile, Ala., and Mississippi Sound, New Orleans, La., 18; Galveston, Tex., 19; lake ports in New York, San Diego, Cal., islands in San Francisco Bay, and north side of San Francisco Bay, Cal., San Francisco, Cal., on south side of bay, 20; mouth of Columbia River, Puget Sound, 21; estimates for 1898–99, 22.

RIVER AND HARBOR IMPROVEMENTS.

General statement, 22; establishment of harbor lines, 23; examination of bills for bridges, Bartrand River, S. C., 24; obstruction of navigable Southern rivers by the aquatic plant known as the water hyacinth, engineer divisions, 25.

ATLANTIC COAST AND GULF OF MEXICO.

In the charge of Lieut. Col. A. N. Damrell and Maj. R. L. Hoxie, Corps of Engineers—

Lubec Channel, Me., 26; Moosabec Bar, Me., 27; Narraguagus River, Me., breakwater from Mount Desert to Porcupine Island, Bar Harbor, Me., 28; harbor at Sullivan Falls, Me., Union River, Me., 29; Bagaduce River, Me., Penobscot River, Me., 30; Belfast Harbor, Me., Camden Harbor, Me., 32; Rockland Harbor, Me., 33; Carvers Harbor, Vinalhaven, Me., 34; Georges River, Me., Kennebec River, Me., 35; Sasanoa River, Me., Portland Harbor, Me., 37; Saco River, Me., 39; Bellamy River, N. H., Cocheco River, N. H., 40; harbor of refuge at Little Harbor, N. H., 41; removing sunken vessels or craft obstructing or endangering navigation, examinations and surveys, 42.

In the charge of Lieut. Col. S. M. Mansfield, Corps of Engineers—

Newburyport Harbor, Mass., 45; Merrimac River, Mass., 46; Powow River, Mass., 47; Essex River, Mass., 48; harbor of refuge, Sandy Bay, Cape Ann, Mass., harbor at Gloucester, Mass., 49; harbor at Manchester, Mass., 51; harbor at Lynn, Mass., 52; Mystic and Malden rivers, Mass., 53; harbor at Boston, Mass., 55; Town River, Mass., 57; Weymouth River, Mass., 58; harbor at Scituate, Mass., 59; harbor at Plymouth, Mass., 61; harbor at Provincetown, Mass., harbor at Chatham, Mass., 62; removing sunken vessels or craft obstructing or endangering navigation, examinations and surveys, 63.

In the charge of Maj. D. W. Lockwood, Corps of Engineers—

Harbor of refuge at Hyannis, Mass., 66; harbor of refuge at Nantucket, Mass., 67; Marthas Vineyard inner harbor at Edgartown, Mass., 68; harbor at Vineyard Haven, Mass., Woods Hole Channel, Mass., 69; New Bedford Harbor, Mass., 70; Canapitsit Channel, Mass., Taunton River, Mass., 71; Sakonnet River, R. I., 72; Pawtucket River, R. I., 73; Providence River and Narragansett Bay, R. I., 74; removal of Green Jacket Shoal, Providence, R. I., harbor at Wickford, R. I., 75; Newport Harbor, R. I., 76; harbor of refuge at Point Judith, R. I., 77; entrance to Point Judith Pond, R. I., harbor of refuge at Block Island, R. I., 78; Great Salt Pond, Block Island, R. I., 79; removing sunken vessels or craft obstructing or endangering navigation, examination and surveys, 80.

In the charge of Maj. Smith S. Leach, Corps of Engineers—

Pawcatuck River, R. I. and Conn., 82; harbor of refuge at Stonington, Conn., 83; Mystic River, Conn., 84; Thames River, Conn., 85; Connecticut River below Hartford, Conn., 86; harbor of refuge at Duck Island Harbor, Conn., New Haven Harbor, Conn., 89; breakwaters at New Haven, Conn., 91; Housatonic River, Conn., 92; Bridgeport Harbor, Conn., 94; Saugatuck River and Westport Harbor, Conn., 96; Norwalk Harbor, Conn., 98; Five Mile River Harbor, Conn., Stamford Harbor, Conn., 100; harbor at Coscob and Mianus River, Conn., 102; Greenwich Harbor, Conn., 103; surveys, 104.

In the charge of Col. G. L. Gillespie and Lieut. Col. William Ludlow, Corps of Engineers—

Hudson River, N. Y., 105; Saugerties Harbor, N. Y., 107; harbor at Rondout, N. Y., 108; harbor at Peekskill, N. Y., 109; Harlem River, N. Y., 110; East River and Hell Gate, N. Y., 111; New York Harbor, N. Y., 113; removing sunken vessels or craft obstructing or endangering navigation, examinations and survey, 114.

In the charge of Maj. H. M. Adams, Corps of Engineers—

Port Chester Harbor, N. Y., 116; Mamaroneck Harbor, N. Y., 117; East Chester Creek, N. Y., Bronx River, N. Y., 118; Mattituck Harbor, N. Y., 119; Port Jefferson Harbor, N. Y., 120; Huntington Harbor, N. Y., 121; Glencove Harbor, N. Y., 122; Flushing Bay, N. Y., Patchogue River, N. Y., 123; Browns Creek, Sayville, N. Y., 124; Canarsie Bay, N. Y., Bay Ridge Channel, the triangular area between Bay Ridge and Red Hook channels, and Red Hook and Buttermilk channels, in the harbor of New York, 125; Gowanus Creek Channel, New York Harbor, 127; Newtown Creek, N. Y., 128; Passaic River, N. J., 129; channel between Staten Island and New Jersey, 130; Elizabeth River, N. J., 131; Raritan River, N. J., 132; South River, N. J., Raritan Bay, N. J., 133; Mattawan Creek, N. J., 134; Keyport Harbor, N. J., 135; Shoal Harbor and Compton Creek, N. J., 136; Shrewsbury River, N. J., 137; removing sunken vessels or craft obstructing or endangering navigation, 138; examinations and surveys, 139.

In the charge of Maj. C. W. Raymond, Corps of Engineers—

Delaware River, N. J. and Pa., 142; harbor between Philadelphia, Pa., and Camden, N. J., 144; Schuylkill River, Pa., 145; ice harbor at Marcushook, Pa., 146; construction of iron pier in Delaware Bay near Lewes, Del., 147; Delaware Breakwater, Del., 148; harbor of refuge, Delaware Bay, Del., 149; Rancocas River, N. J., Alloway Creek, N. J., 150; Dennis Creek, N. J., 151; Cooper Creek, N. J., 152; Goshen Creek, N. J., removing sunken vessels or craft obstructing or endangering navigation, examinations and survey, 153.

In the charge of Wm. F. Smith, United States Agent, Major of Engineers, U. S. Army, retired—

Wilmington Harbor, Del., 155; Nanticoke River, Del. and Md., 157; Appoquinimink River, Del., 158; Smyrna River, Del., 159; Murderkill River, Del., 160; Mispillion River, Del., 161; Broadkiln River, Del., inland waterway from Chincoteague Bay, Va., to Delaware Bay at or near Lewes, Del., 162; Susquehanna River above and below Havre de Grace, Md., 163; Chester River, Md., from Crumpton to Jones Landing, Choptank River, Md., 164; La Trappe River, Md., 165; Warwick River, Md., 166; Broad Creek River, Del., 167; Wicomico River, Md., Manokin River, Md., 168; Pocomoke River, Md., Queenstown Harbor, Md., 169; Rockhall Harbor and inner harbor at Rockhall, Md., removing sunken vessels or craft obstructing or endangering navigation, 170; examinations and surveys, 171.

In the charge of Col. Peter C. Hains, Corps of Engineers—

Patapsco River and channel to Baltimore, Md., 172; channel to Curtis Bay, in Patapsco River, Baltimore Harbor, Md., 173; harbor of southwest Baltimore (Spring Garden), Md., removing sunken vessels or craft obstructing or endangering navigation, surveys, 174.

In the charge of Lieut. Col. Chas. J. Allen, Corps of Engineers—

Potomac River at Washington, D. C., 175; Occoquan Creek, Va., 177; Aquia Creek, Va., Nomini Creek, Va., 179; Lower Machodoc Creek, Va., Rappahannock River, Va., 181; Urbana Creek, Va., 183; York River, Va., 184; Mattaponi River, Va., 185; Pamunkey River, Va., James River, Va., 187; protection of Jamestown Island, Va., survey, 189.

In the charge of Capt. Thos. L. Casey, Corps of Engineers—

Harbor at Norfolk and its approaches, Va., 190; Western Branch of Elizabeth River, Va., 191; Nansemond River, Va., 192; Appomattox River, Va., 193; harbor at Cape Charles City, Va., 194; Nandua Creek, Va., inland water route from Norfolk Harbor, Va., to Albemarle Sound, N. C., through Currituck Sound, 195; North Landing River, Va. and N. C., Roanoke River, N. C., 196; Pasquotank River, N. C., 197; removing sunken vessels or craft obstructing or endangering navigation, examinations, 198.

In the charge of Lieut. Col. D. P. Heap and Capt. W. E. Craighill, Corps of Engineers—

Ocracoke Inlet, N. C., 199; Fishing Creek, N. C., 200; Pamlico and Tar rivers, N. C., 201; Contentnia Creek, N. C., Trent River, N. C., 202; Neuse River, N. C., 203; inland waterway between Newbern and Beaufort, N. C., harbor at Beaufort, N. C., 204; inland waterway between Beaufort Harbor and New River, N. C., 205; New River, N. C., 206; North East (Cape Fear) River, N. C., Black River, N. C., 207; Cape Fear River above Wilmington, N. C., 208; Cape Fear River at and below Wilmington, N. C., 209; Lockwoods Folly River, N. C., examination and surveys, 211.

In the charge of Capt. Frederic V. Abbot, Corps of Engineers—

Waccamaw River, N. C. and S. C., 213; Lumber River, N. C. and S. C., 214; Little Pedee River, S. C., 215; Great Pedee River, S. C., 216; Mingo Creek, S. C., Winyah Bay, S. C., 217; Santee River, S. C., 219; Wateree River, S. C., 220; Congaree River, S. C., 221; Charleston Harbor, including Mount Pleasant and Sullivan Island shore, S. C., 222; Wappoo Cut, S. C., 223; Beaufort River, S. C., 224.

In the charge of Capt. O. M. Carter, Corps of Engineers—

Savannah Harbor, Ga., 224; Savannah River between Savannah and Augusta, Ga., 227; Savannah River above Augusta, Ga., 228; Darien Harbor, Ga., 229; Altamaha River, Ga., 230; Oconee River, Ga., 231; Ocmulgee River, Ga., 232; Brunswick Harbor, Ga., 233; Cumberland Sound, Ga., 235; inside water route between Savannah, Ga., and Fernandina, Fla., 236; removing sunken vessels or craft obstructing or endangering navigation, survey, 237.

In the charge of Lieut. Col. W. H. H. Benyaurd, Corps of Engineers—

St. Johns River, Fla., 238; Volusia Bar, Fla., 240; Ocklawaha River, Fla., 241; St. Augustine Harbor, Fla., Indian River, Fla., Negro Cut, Jupiter Inlet, Fla., 242; northwest entrance, Key West Harbor, Fla., 244; Caloosahatchee River, Fla., 245; Charlotte Harbor and Pease Creek, Fla., 246; Sarasota Bay, Fla., 247; Manatee River, Fla., 248; Withlacoochee River, Fla., Suwanee River, Fla., 249; removing sunken vessels or craft obstructing or endangering navigation, examinations and surveys, 251.

IN THE CHARGE OF MAJ. F. A. MAHAN, CORPS OF ENGINEERS—

Carrabelle Bar and Harbor, Fla., 253; Apalachicola Bay, Fla., Apalachicola River, the Cut-off, and lower Chipola River, Fla., 254; Flint River, Ga., 255; Chattahoochee River, Ga. and Ala., below Columbus, 256; Chattahoochee River, between Westpoint and Franklin, Ga., Choctawhatchee River, Fla. and Ala., 257; harbor at Pensacola, Fla., 258; Escambia and Conecuh rivers, Fla. and Ala., 259; Alabama River, Ala., 260; improvement of, and operating and care of canals and other works of navigation on, Coosa River, Ga. and Ala., 261, 262; survey, 262.

IN THE CHARGE OF MAJ. WM. T. ROSSELL, CORPS OF ENGINEERS—

Mobile Harbor, Ala., 263; improvement of, and operation and care of locks and dams on, Black Warrior River, Ala., 264, 265; Warrior and Tombigbee rivers, Ala., 265; Tombigbee River from mouth to Demopolis, Ala., 266; Tombigbee River, from Demopolis, Ala., to Columbus, Miss., 267; Tombigbee River, from Fulton to Columbus, Miss., and from Walkers Bridge to Fulton, Miss., 268; Noxubee River, Miss., Pascagoula River, Miss., 269; Chickasahay River, Miss., 271; Leaf River, Miss., Pearl River, below Jackson, Miss., 272; Pearl River between Carthage and Jackson, Miss., 273; Pearl River, between Edinburg and Carthage, Miss., Bogue Chitto, La., 274; survey of canal from Birmingham, Ala., to the Warrior River, Ala., examinations and surveys, 275.

IN THE CHARGE OF MAJ. JAMES B. QUINN, CORPS OF ENGINEERS—

Inspection of the improvement of the South Pass of the Mississippi River, 277; Chefuncte River and Bogue Falia, La., 278; Tickfaw River and tributaries, La., 279; Amite River and Bayou Manchac, La., 280; Bayou Lafourche, La., 281; Bayou Plaquemine, Grand River, and Pigeon bayous, La., 282; Bayou Courtableau, La., 283; Bayou Teche, La., 284; Bayou Vermilion, La., Mermentau River and tributaries, La., 285; mouth and passes of Calcasieu River, La., 286; harbor at Sabine Pass, Tex., 288; Sabine River, Tex., 289; Neches River, Tex., 290; closing crevasse in Pass a Loutre, Mississippi River, removing sunken vessels or craft obstructing or endangering navigation, examinations and surveys, 291.

IN THE CHARGE OF MAJ. A. M. MILLER, CORPS OF ENGINEERS—

Galveston Harbor, Tex., 292; ship channel in Galveston Bay, Tex., 294; channel in West Galveston Bay, Tex., 295; Trinity River, Tex., Buffalo Bayou, Tex., 296; Brazos River, Tex., 297; operating and care of Morgan Canal, Tex., examination and survey, 298.

IN THE CHARGE OF A BOARD OF ENGINEERS, COL. HENRY M. ROBERT, CORPS OF ENGINEERS, SENIOR MEMBER—

Ascertaining the character and value of the improvements made at the mouth of the Brazos River, Tex., by the Brazos River Channel and Dock Company, 298.

WESTERN RIVERS.

IN THE CHARGE OF MAJ. J. H. WILLARD, CORPS OF ENGINEERS—

Red River, La. and Ark., 299; Red River, above Fulton, Ark., 300; Cypress Bayou, Tex. and La., 301; Ouachita and Black rivers, Ark. and La., 302; Bayou Bartholomew, La. and Ark., Bœuf River, La., 303; Tensas River and Bayou Maçon, La., 304; Yazoo River, Miss., 305; mouth of Yazoo River and harbor at Vicksburg, Miss., 306; Tallahatchie River, Miss., Big Sunflower River, Miss., 308; water gauges on the Mississippi River and its principal tributaries, 309; examination, 310.

IN THE CHARGE OF CAPT. WILLIAM L. SIBERT, CORPS OF ENGINEERS—

Removing obstructions in Arkansas River, Ark. and Kans., 310; Arkansas River, Ark., 311; White River, Ark., 312; Black River, Ark. and Mo., 313; Current River, Ark. and Mo., St. Francis River, Ark., 314; St. Francis River, Mo., 315; examination and surveys, 316.

IN THE CHARGE OF MAJ. THOMAS H. HANDBURY, CORPS OF ENGINEERS—

Removing snags and wrecks from Mississippi River, 317; Mississippi River between Ohio and Missouri rivers, 318; harbor at St. Louis, Mo., 320; preventing the Mississippi River from breaking through into the Cache River at or near a point known as Beach Ridge, a few miles above Cairo, Ill., 321.

In the charge of Lieut. Col. W. R. King, Corps of Engineers—

Operating snag boats and dredge boats on Upper Mississippi River, 321; Mississippi River between Missouri River and Minneapolis, Minn., 322; operating and care of Des Moines Rapids Canal and Dry Dock, operating and care of Galena River improvement, Ill., Mississippi River between St. Paul and Minneapolis, Minn., (construction of Lock and Dam No. 2), 323; surveys, 324.

In the charge of Lieut. Col. W. A. Jones, Corps of Engineers—

Construction and operating and care of reservoirs at head waters of Mississippi River, 326, 328; Chippewa River, including Yellow Banks, Wis., 328; St. Croix, River, Wis. and Minn., 329; Minnesota River, Minn., Red River of the North, Minn. and N. Dak., 330; gauging Mississippi River at or near St. Paul, Minn., examinations, 332.

In the charge of Lieut. Col. W. A. Jones and Capt. J. C. Sanford, Corps of Engineers—

Missouri River between Stubbs Ferry, Mont., and the lower limits of Sioux City, Iowa, 333; improving Upper Missouri River by snagging, 337; Yellowstone River, Mont. and N. Dak., 338.

In the charge of Capt. John Biddle, Corps of Engineers—

Obion River, Tenn., 339; Forked Deer River, Tenn., 340; North or Middle Fork, Forked Deer River, and Obion River, 341; Cumberland River, Tenn. and Ky.—below Nashville, 342; above Nashville, 344; surveys, 347.

In the charge of Capt. Dan C. Kingman, Corps of Engineers—

Tennessee River system, 348; Tennessee River above and below Chattanooga, Tenn., 348, 349; operating and care of Muscle Shoals Canal, Tennessee River, Ala., 351; French Broad, and Little Pigeon rivers, Tenn., 352; Clinch River, Tenn., 353; surveys, 354.

In the charge of Maj. W. H. Heuer, Corps of Engineers—

Ohio River, 355; operating snag boat on the Ohio River, operating and care of Davis Island Dam, Ohio River, near Pittsburg, construction of movable dams Nos. 2, 3, 4, 5, and 6 in the Ohio River, 356; improvement of, and operating and care of locks and dams on Muskingum River, Ohio, 358; examination, 359.

In the charge of Maj. Charles F. Powell and Maj. R. L. Hoxie, Corps of Engineers—

Improvement of, and operation and care of locks and dams Nos. 8 and 9, Monongahela River, W. Va. and Pa., 359, 360; purchase of locks and dams Nos. 6 and 7, Monongahela River, condemnation of all the property and appurtenances of the Monongahela Navigation Company, 361; Allegheny River, Pa., 362; construction of locks and dams at Herr Island, above the head of Six Mile Island, and at Springdale, Allegheny River, 363.

In the charge of Capt. J. G. Warren, Corps of Engineers—

Falls of the Ohio River at Louisville, Ky., and Indiana Chute, Falls of the Ohio River, 364, 365; operating and care of Louisville and Portland Canal, Ky., Wabash River above and below Vincennes, Ind., 366; operating and care of lock and dam at Grand Rapids, Wabash River, White River, Ind., 368; Tradewater River, Ky., construction of Lock No. 2, Green River, at Rumsey, Ky., 369; Green River above mouth of Big Barren River, Ky., operating and care of locks and dams on Green and Barren rivers, Ky., 370; Rough River, Ky., 371; examination and surveys, 372.

In the charge of Maj. James F. Gregory, Corps of Engineers—

Improvement of, and operating and care of locks and dams on, Kentucky River, Ky., 373, 375; Tug Fork of Big Sandy River, W. Va. and Ky., 375; Levisa Fork of Big Sandy River, Ky., 376; Big Sandy River, W. Va. and Ky., 377; Guyandotte River, W. Va., 378; New River, Va. and W. Va., 379; Gauley River, W. Va., Elk River, W. Va., 380; improvement of, and operating and care of locks and dams on, Great Kanawha River, W. Va., 381, 383; improvement of, and operating and care of lock and dam on, Little Kanawha River, W. Va., 384.

LAKE RIVERS AND HARBORS.

In the charge of Maj. Clinton B. Sears, Corps of Engineers—

Harbor at Grand Marais, Minn., 385; harbor at Agate Bay, Minn., harbor at Duluth, Minn., and Superior, Wis., 386; harbor at Ashland, Wis., 388; harbor at Ontonagon, Mich., 389; improvement of, and operating and care of, waterway across Keweenaw Point from Keweenaw Bay to Lake Superior, Mich., 389, 390; harbor at Marquette, Mich., harbor of refuge at Presque Ile Point, Marquette Bay, Mich., 391; harbor of refuge at Grand Marais, Mich., 392; examination, 393.

In the charge of Capt. Geo. A. Zinn, Corps of Engineers—

Menominee Harbor, Mich. and Wis., Menominee River, Mich. and Wis., 393; Oconto Harbor, Wis., 394; Pensaukee Harbor, Wis., Green Bay Harbor, Wis., 395; improvement of, and operating and care of, Sturgeon Bay and Lake Michigan Ship Canal, Wis., 396, 397; Sturgeon Bay Canal harbor of refuge, Wis., 397; Ahnapee Harbor, Wis., 398; Kewaunee Harbor, Wis., Two Rivers Harbor, Wis., 399; Manitowoc Harbor, Wis., 400; Sheboygan Harbor, Wis., Port Washington Harbor, Wis., 401; harbor of refuge, Milwaukee, Wis., 402; Milwaukee Harbor, Wis., South Milwaukee Harbor, Wis., 403; Racine Harbor, Wis., Kenosha Harbor, Wis., 404; Waukegan Harbor, Ill., 405; improvement of, and operating and care of locks and dams on, Fox River, Wis., 406, 407; removing sunken vessels or craft obstructing or endangering navigation, 407; surveys, 408.

In the charge of Maj. W. L. Marshall, Corps of Engineers—

Chicago Harbor, Ill., 409; Chicago River, Ill., 411; Calumet Harbor, Ill., 412; Calumet River, Ill. and Ind., 414; Illinois River, Ill., 415; operating and care of Lagrange and Kampsville locks, Illinois River, and approaches thereto, 417; Illinois and Mississippi Canal, 418; operating and care of Illinois and Mississippi Canal: canal around lower rapids of Rock River at Milan, Ill., removing sunken vessels or craft obstructing or endangering navigation, 420; examination and survey, 421.

In the charge of Lieut. Col. G. J. Lydecker and Capt. C. McD. Townsend, Corps of Engineers—

Michigan City inner and outer harbors, Ind., 421; St. Joseph Harbor, Mich., 423; St. Joseph River, Mich., South Haven Harbor, Mich., 424; Saugatuck Harbor, Mich., 425; Kalamazoo River, Mich., Holland (Black Lake) Harbor, Mich., 426; Grand Haven Harbor, Mich., 427; Grand River, Mich., Muskegon Harbor, Mich., 428; White Lake Harbor, Mich., 429; Pentwater Harbor, Mich., Ludington Harbor, Mich., 430; Manistee Harbor, Mich., harbor of refuge at Portage Lake, Manistee County, Mich., 431; Frankfort Harbor, Mich., 432; Charlevoix Harbor, Mich., 433; Petoskey Harbor, Mich., removing sunken vessels or craft obstructing or endangering navigation, surveys, 434.

In the charge of Lieut. Col. G. J. Lydecker, Corps of Engineers—

Ship channel connecting waters of the Great Lakes between Chicago, Duluth, and Buffalo, 435; St. Marys River at the falls, Mich., 437; operating and care of St. Marys Falls Canal, 438; Hay Lake Channel, St. Marys River, Mich., 439; Cheboygan Harbor, Mich., 440; Alpena Harbor (Thunder Bay River), Mich., 441; Saginaw River, Mich., 442; Sebewaing River, Mich., 443; harbor of refuge at Sand Beach, Lake Huron, Mich., 444; improvement of, and operating and care of, St. Clair Flats Canal, Mich., 445; mouth of Black River, Mich., Black River at Port Huron, Mich., 446; Pine River, Mich., 447; Belle River, Mich., 448; Clinton River, Mich., Detroit River, Mich., 449; Rouge River, Mich., 450; turning basin in Rouge River, Mich., removing sunken vessels or craft obstructing or endangering navigation, examination, 451.

In the charge of Col. Jared A. Smith, Corps of Engineers—

Monroe Harbor, Mich., Toledo Harbor, Ohio, 452; Port Clinton Harbor, Ohio, Sandusky Harbor, Ohio, 454; Huron Harbor, Ohio, 455; Vermilion Harbor, Ohio, 456; Black River (Lorain) Harbor, Ohio, 457; Cleveland Harbor, Ohio, 458; Fairport Harbor, Ohio, 459; Ashtabula Harbor, Ohio, 460; Conneaut Harbor, Ohio, 461; examination, 463.

In the charge of Maj. Thomas W. Symons, Corps of Engineers—

Erie Harbor, Pa., 463; harbor at Dunkirk, N. Y., 464; Buffalo Harbor, N. Y., 466; Tonawanda Harbor and Niagara River, N.Y., 469; Niagara River from Tonawanda to Port Day, N. Y., 470; Wilson Harbor, N. Y., 471; removing sunken vessels or craft obstructing or endangering navigation, examination and surveys, 472, report upon House bill No. 7775, 54th Congress, first session, providing for widening the locks of Erie Canal, N. Y., 473.

In the charge of Maj. W. S. Stanton, Corps of Engineers—

Harbor at Charlotte, N. Y., harbor at Pultneyville, N. Y., 474; harbor at Great Sodus Bay, N. Y., harbor at Little Sodus Bay, N. Y., 475; harbor at Oswego, N. Y., 476; harbor at Sacketts Harbor, N. Y., harbor at Cape Vincent, N. Y., 477; shoals between Sister Islands and Crossover Light, and between Ogdensburg and the foot of Lake Ontario, St. Lawrence River, 478; harbor at Ogdensburg, N. Y., 479; harbor at Burlington, Vt., channel between North and South Hero islands, Lake Champlain, Vt., 480; Otter Creek, Vt., Narrows of Lake Champlain, N. Y. and Vt., 481; removing sunken vessels or craft obstructing or endangering navigation, examinations and surveys, 482; report upon House bill No. 8074, 54th Congress, first session, providing for widening the locks of Oswego Canal, N. Y., 483.

PACIFIC COAST.

In the charge of Col. Chas. R. Suter, Corps of Engineers—

Oakland Harbor, Cal., 484.

In the charge of Maj. Chas. E. L. B. Davis, Corps of Engineers—

San Luis Obispo Harbor, Cal., 485; Wilmington Harbor, Cal., 486; San Diego Harbor, Cal., examinations and surveys, 487.

In the charge of Capt. Cassius E. Gillette, Corps of Engineers—

San Joaquin River, Cal., 488; Mokelumne River, Cal., 489; Sacramento and Feather rivers, Cal., 490; Napa River, Cal., 491; Petaluma Creek, Cal., Humboldt Harbor and Bay, Cal., 492, examinations, 494.

In the charge of Capt. W. L. Fisk, Corps of Engineers—

Port Orford Harbor, Oreg., 494; Coquille River, Oreg. (general improvement), 495; Coquille River, Oreg., between Coquille City and Myrtle Point, entrance to Coos Bay and Harbor, Oreg., 496; harbor at Coos Bay, Oreg. (dredging), 497; Coos River, Oreg., Umpqua River, Oreg., mouth of Siuslaw River, Oreg., 498; Alsea River, Oreg., Yaquina Bay, Oreg., 499; Nestugga River, Oreg., Tillamook Bay and Bar, Oreg., 501; mouth of Columbia River, Oreg. and Wash., Columbia River, Oreg., below Tongue Point, 502; Columbia and Lower Willamette rivers below Portland, Oreg., 503; Columbia River between Vancouver, Wash., and the mouth of Willamette River, canal at the Cascades, Columbia River, Oreg., 504; operating and care of canal and locks at the Cascades of the Columbia River, Oreg., Columbia River at Three Mile Rapids, and the construction and equipment of a boat railway from the foot of The Dalles Rapids to the head of Celilo Falls, Oreg. and Wash., 505; Willamette River above Portland and Yamhill River, Oreg., 506; gauging waters of Columbia River, Oreg. and Wash., 507.

In the charge of Capt. Harry Taylor, Corps of Engineers—

Willapa River and Harbor, Wash., 508; Grays Harbor and bar entrance, Wash., 509; Chehalis River, Wash., 510; Puget Sound and its tributary waters, Wash., 511; harbor at Olympia, Wash., 512; waterway connecting Puget Sound with lakes Union and Washington, 513; Everett Harbor, Wash., 515; Swinomish Slough, Wash., 516; Columbia River from Rock Island Rapids to Foster Creek Rapids, Wash., 517; Upper Columbia and Snake rivers, Oreg. and Wash., 518; Cowlitz River, Wash., 520; Clearwater River, Idaho, Kootenai River, Idaho, between Bonners Ferry and the international boundary line, 521; Flathead River, Mont., 522; examinations and surveys, 523.

EXAMINATIONS, SURVEYS, AND CONTINGENCIES OF RIVERS AND HARBORS.................................. 524

SURVEY OF PORTLAND CHANNEL (CANAL), ALASKA.

In the charge of Capt. D. D. Gaillard, Corps of Engineers............ 524

SUPERVISION OF THE HARBOR OF NEW YORK.

Lieut. Commander Daniel Delehanty and Lieut. John F. Parker, U. S. N., Supervisors 524

MISSISSIPPI RIVER COMMISSION 525

MISSOURI RIVER COMMISSION 527

CALIFORNIA DÉBRIS COMMISSION 528

BRIDGING NAVIGABLE WATERS OF THE UNITED STATES.

Under authority of special acts of Congress.—(1) Bridge of the Boonville and Howard County Bridge Company across Missouri River at Boonville, Mo., (2) bridge of the Yankton Bridge Company across Missouri River at Yankton, S. Dak., (3) bridge of the Union Railroad Company across Monongahela River between Port Perry and Mifflin Township, Pa., (4) bridge of the city of Detroit, Mich., across west channel of Detroit River, 529; (5) bridge of the Braddock and Duquesne Bridge Company across Monongahela River between Braddock and Mifflin townships, Pa., (6) bridge of the Aransas Harbor Terminal Railway Company across Corpus Christi Channel (Morris and Cummings Ship Channel), Tex., (7) bridge of the Delta Cooperage Company and the Yazoo and Mississippi Valley Railroad Company across Tallahatchie River at Philipp, Miss., (8) bridge of Roane County, across Clinch River at Kingston, Tenn., (9) bridge of the Mobile and Ohio Railroad Company across Cahaba River, in Bibb County, Ala., (10) bridge of the Mobile and Ohio Railroad Company across Alabama River, near Montgomery, Ala., (11) bridge of Marion County, Miss., across Pearl River, (12) bridge of the city of Monroe, La., across Ouachita River at De Siard street, (13) bridge of the Mobile and Ohio Railroad Company across Warrior River, in Tuscaloosa County, Ala., 530; (14) bridge of the St. Francis Bridge and Turnpike Company across Lake St. Francis at or near Lake City, Ark., (15) bridge of the Northern New York Railroad Company across St. Lawrence River, near Hogansburg, N. Y., 531.

Under authority of State laws.—(1) Bridge of the Texarkana and Fort Smith Railway Company across Neches River at Beaumont, Tex., (2) bridge of the Seattle and Rainier Beach Railway Company across Black River, Wash., (3) bridge of the Kansas City, Shreveport and Gulf Railway Company across Calcasieu River at Lake Charles, La., (4) bridge of the Lake Shore and Michigan Southern Railway Company across Swan Creek at Toledo, Ohio, (5) bridge of the Kansas City, Osceola and Southern Railway Company across Osage River at Osceola, Mo., (6) bridge of Bristol County, Mass., across Acushnet River between New Bedford and Fairhaven, 531; (7) bridge of the Queen Anne's Railroad Company across Choptank River at Denton, Md., (8) bridge of the city of New York across East River at Delancey street, (9) bridge of the city of Appleton, Wis., across United States Fox River Canal at John street, (10) bridge of the city of Green Bay, Wis., across East River, (11) bridge of the city of Green Bay, Wis., across Fox River at Main street, (12) bridge of Monmouth and Ocean counties, N. J., across Manasquan River between Manasquan and Point Pleasant, (13) bridge of the town of Jeanerette, La., across Bayou Teche, (14) bridge of Essex County, Mass. (Essex Bridge), across Beverly Harbor between Salem and Beverly, 532; (15) bridge of the Superior Rapid Transit Railway Company and the Duluth Street Railway Company across St. Louis River between Duluth, Minn., and Superior, Wis., (16) bridge of Shasta County, Cal., across Sacramento River at Balls Ferry, (17) bridge of the New York, New Haven and Hartford Railroad Company across Pequonnock River at Bridgeport, Conn., (18) bridge of the West Braddock Bridge Company across Monongahela River at Rankin, Pa., (19) bridge of the town of Hempstead, N. Y., across Long Beach Channel from Barnum Island to Inner Beach, (20) bridge of the city of Menasha, Wis., across Fox River, (21) bridge of the town of Oyster Bay, N. Y., across Mill Neck Creek Inlet from Allens Point at Mill Neck to Pine Island at Bayville, (22) bridges of the Chicago and Northwestern Railway Company across Kinnickinick River at Milwaukee, Wis., (23) bridge of the New York, Philadelphia and Norfolk Railroad Company across the Southern Branch of Elizabeth River at Norfolk, Va., (24) bridge of the Astoria and Columbia River Railroad Company across Blind Slough, Oreg., (25) bridge of the St. Joseph Valley Railway Company across St. Joseph River, Mich., (26) bridge of Jefferson County, Tex., across Hillebrandt Bayou, (27) bridge of the Allegheny and Westmoreland Bridge Company across Youghiogheny River at Sutersville, Pa., 533; (28) bridge of the city of Philadelphia, Pa., across Schuylkill River, (29) bridge of the city of New Haven, Conn., across Mill River at Chapel street, (30) bridge of Mr. J. B. Levert across Bayou Teche, in St. Martin Parish, La., (31) bridge of the Houston, East and West Texas Railway Company across Trinity River above Marianna, Tex., (32) bridge of the town of Yarmouth, Me., across Casco Bay, between Cousins and Littlejohns islands, (33) bridge of the Lake Shore and Michigan Southern Railway Company across Ashtabula River at Ashtabula, Ohio, (34) bridge of the city of Brooklyn, N. Y., across Coney Island Creek from West Seventeenth street to West Eighteenth street, (35) bridge of the city of Manitowoc, Wis., across Manitowoc River at Main street, (36) bridge of the Portsmouth, Kittery and York Street Railway Company across Piscataqua River channel between Kittery and Badgers Island, Me., (37) bridge of the Portsmouth, Kittery and York Street Railway Company across Brave Boat Harbor between Kittery and York, Me., (38) bridge of the city of Port Huron, Mich., across Black River at Tenth street, (39) bridges of the town of Bourne, Mass., across Monument and Back rivers, (40) bridge of St. Martin Parish, La., across Bayou Teche at St. Martinville, (41) bridge of Walton County across Alequa Creek near Portland, Fla., 534; (42) temporary bridge of the Union Street Railway Company across Acushnet River between Popes Island and Fish Island, New Bedford Harbor, Mass., (43) bridge of the Vermont and Province Line Railroad Company across Missisquoi Bay at Alburgh Point, Vt., (44) bridge of Iberville Parish across Bayou Plaquemine at Plaquemine, La., 535.

Alterations.—(1) Bridge of the Southern Pacific Company across Oakland Harbor, Cal., at Alice street; (2) bridge of the city of Brooklyn and the county of Queens, N. Y., across Newtown Creek, at Vernon avenue, Long Island City; (3) bridge of the city of Portland (Tukeys Bridge), across Back Cove, Portland Harbor, Me., 535.

BRIDGE OBSTRUCTING NAVIGATION.

Bridge of the city of New York across Harlem River at One hundred and fifty-sixth street, 536.

OCCUPANCY OF AND INJURY TO PUBLIC WORKS BY CORPORATIONS AND INDIVIDUALS 536

MISCELLANEOUS.

REPAIR OF THE AQUEDUCT BRIDGE ACROSS POTOMAC RIVER AT WASHINGTON, D. C.

IN THE CHARGE OF LIEUT. COL. CHAS. J. ALLEN, CORPS OF ENGINEERS.........536

MAINTENANCE AND REPAIR OF WASHINGTON AQUEDUCT AND INCREASING THE WATER SUPPLY OF WASHINGTON, D. C.

IN THE CHARGE OF LIEUT. COL. CHAS. J. ALLEN AND CAPT. D. D. GAILLARD, CORPS OF ENGINEERS—

Washington Aqueduct, 537; increasing the water supply of Washington, D. C., 540.

PUBLIC BUILDINGS AND GROUNDS AND WASHINGTON MONUMENT, DISTRICT OF COLUMBIA.

IN THE CHARGE OF COL. (NOW BRIG. GEN.) JOHN M. WILSON, CORPS OF ENGINEERS, COL. THEO. A. BINGHAM, U. S. A., AND LIEUT. JOHN S. SEWELL, CORPS OF ENGINEERS 542

NORTHERN AND NORTHWESTERN LAKES.

SURVEYS, printing, and issuing of charts, 544, 545; correcting engraved plates, estimates, preservation of bench marks along the Erie Canal, 546; examination of shoals in Lake Erie, water levels, 547.

MAPS AND PLANS.............................. 547

RECONNAISSANCES AND EXPLORATIONS.

OFFICERS on duty at headquarters of military departments, 547; operations in Department of the Missouri, Department of the Columbia, Department of California, 548; Department of the Colorado, 549.

ESTIMATES FOR AMOUNTS REQUIRED FOR SURVEYS AND RECONNAISSANCES IN MILITARY DEPARTMENTS, AND FOR MAPS, INCLUSIVE OF WAR MAPS.............................. 549

OFFICE OF THE CHIEF OF ENGINEERS.

OFFICERS on duty, 550.

FORTIFICATIONS, ETC.

APPENDIX No. 1.

REPORT OF THE BOARD OF ENGINEERS.

Changes in personnel during the year, members, summary of reports, 553; inspection of sites for defense of New Orleans, La., and the mouth of the Mississippi River, additional duties of members, 556.

APPENDIX No. 2.

REPORT OF MAJ. JOHN G. D. KNIGHT, CORPS OF ENGINEERS.

Post of Willets Point, N. Y., 559; United States Engineer School, 562; Battalion of Engineers, 570; Engineer Depot, 574.

APPENDIX No. 3.

FORTIFICATIONS, FISCAL YEAR 1896-97.

(A) Coasts of Maine and New Hampshire. (In the charge of Lieut. Col. A. N. Damrell and Maj. R. L. Hoxie, Corps of Engineers.)—Portland Harbor, Me., 581; Portsmouth Harbor, N. H., 597.

(B) Boston Harbor, Mass. (In the charge of Lieut. Col. S. M. Mansfield, Corps of Engineers.)—600.

(C) Southeast Coast of Massachusetts and Rhode Island. (In the charge of Maj. D. W. Lockwood, Corps of Engineers.)—Narragansett Bay, 603.

(D) Eastern Entrance to Long Island Sound. (In the charge of Maj. Smith S. Leach, Corps of Engineers.)—608.

(E) New York Harbor, N. Y.—At Eastern Entrance, on Islands in Harbor, and on Staten Island. (In the charge of Maj. H. M. Adams and Maj. John G. D. Knight, Corps of Engineers.)—610; sea wall at Fort Schuyler, 611; Staten Island, 613.

(F) New York Harbor, N. Y.—At Southern Entrance, on Long Island, and on Sandy Hook. (In the charge of Col. G. L. Gillespie and Lieut. Col. William Ludlow, Corps of Engineers.)—Long Island, 614; Sandy Hook, 618.

(G) Delaware River, N. J., Pa., and Del. (In the charge of Maj. C. W. Raymond, Corps of Engineers.)—628; Fort Mifflin, Pa., 638; Red Bank, N. J., 639.

(H) Baltimore, Md. (In the charge of Col. Peter C. Hains, Corps of Engineers.)—Fort McHenry, Md., 639; Rock Point, Md., 649.

(I) Washington, D. C. (In the charge of Lieut. Col. Chas. J. Allen, Corps of Engineers.)—650.

(J) Hampton Roads, Va. (In the charge of Capt. Thos. L. Casey, Corps of Engineers.)—656; sewerage system, Fort Monroe, 663.

(K) Coast of North Carolina. (In the charge of Lieut. Col. D. P. Heap and Capt. W. E. Craighill, Corps of Engineers.)—670.

(L) Coast of South Carolina. (In the charge of Capt. Frederic V. Abbot, Corps of Engineers.)—675.

(M) Coast of Georgia and Cumberland Sound. (In the charge of Capt. O. M. Carter, Corps of Engineers.)—700.

(N) Coast of Florida. (In the charge of Lieut. Col. W. H. H. Benyaurd, Corps of Engineers.)—Fort Marion, 702; Key West, 703.

(O) Pensacola, Fla. (In the charge of Maj. F. A. Mahan, Corps of Engineers.)—714.

(P) Mobile, Ala., and Mississippi Sound. (In the charge of Maj. Wm. T. Rossell, Corps of Engineers.)—721.

(Q) New Orleans, La. (In the charge of Maj. James B. Quinn and Lieut. C. S. Riché, Corps of Engineers.)—727.

(R) Galveston, Tex. (In the charge of Maj. A. M. Miller, Corps of Engineers.) —737.

(S).Lake Ports in New York.—(In the charge of Maj. W. S. Stanton, Corps of Engineers.)—Fort Niagara, 743; Fort Montgomery, 744.

(T) San Diego, Islands in San Francisco Bay, and North Side of San Francisco Bay, Cal. (In the charge of Maj. Chas. E. L. B. Davis, Corps of Engineers.)—San Francisco, 744; San Diego, 745.

(U) San Francisco, Cal., on South Side of San Francisco Bay. (In the charge of Col. Chas. R. Suter, Corps of Engineers.)—748.

(V) Mouth of Columbia River. (In the charge of Capt. W. L. Fisk, Corps of Engineers.)—756.

(W) Puget Sound, Wash. (In the charge of Capt. Harry Taylor, Corps of Engineers.)—763.

RIVERS AND HARBORS.

APPENDIX A.

REPORT UPON WORKS IN THE CHARGE OF LIEUT. COL. A. N. DAMRELL AND MAJ. R. L. HOXIE, CORPS OF ENGINEERS.

Improvements.—Lubec Channel, Me., 770; Moosabec Bar, Me., 771; Narraguagus River, Me., 773; breakwater from Mount Desert to Porcupine Island, Bar Harbor, Me., 775; harbor at Sullivan Falls, Me., 776; Union River, Me., 777; Bagaduce River, Me., 778; Penobscot River, Me., 779; Belfast Harbor, Me., 781; harbor at Camden, Me., 782; harbor at Rockland, Me., 783; Carvers Harbor, Vinalhaven, Me., Georges River, Me., 785; Kennebec River, Me., 787; Sasanoa River, Me., 789; Portland Harbor, Me., 790; Saco River, Me., 792; Bellamy River, N. H., Cocheco River, N. H., 794; harbor of refuge at Little Harbor, N. H., 796; removing sunken vessels or craft obstructing or endangering navigation, 798.

Examinations and Surveys.—Chandlers River, Me., 798; Union River, near Ellsworth, Hancock County, Me., 800; south channel of branch of Penobscot River, in Frankfort, Waldo County, Me., with a view of removing wreck, 801; Boothbay Harbor, Me., 802; Oyster River, N. H., 804; St. Croix River, below Calais, Me. and N. B., 805; Machias River, Me., from Machias to Machiasport, 809; Bangor Harbor and Penobscot River, including mouth of Kenduskeag River, Me., 811; Harraseeket River, Me., 815; Royal River, Me., 816; Exeter River, N. H., 818.

APPENDIX B.

REPORT OF LIEUT. COL. S. M. MANSFIELD, CORPS OF ENGINEERS.

Improvements.—Newburyport Harbor, Mass., 824; Merrimac River, Mass., 827; Powow River, Mass., 829; Essex River, Mass., 830; harbor of refuge, Sandy Bay, Cape Ann, Mass., 832; harbor at Gloucester, Mass., 835; harbor at Manchester, Mass., 837; harbor at Lynn, Mass., 839; Mystic and Malden rivers, Mass., 841; harbor at Boston, Mass., 843; Town River, Mass., 848; Weymouth River, Mass., 849; harbor at Scituate, Mass., 851; harbor at Plymouth, Mass., 854; harbor at Provincetown, Mass., 856; harbor at Chatham, Mass., 858; removing sunken vessels or craft obstructing or endangering navigation, 859.

Examinations and Surveys.—Duxbury Harbor, Mass., 860; Duxbury Beach, Mass., 862; Gurnet Rock and other rocks at mouth of Plymouth Harbor, Mass., 863; approaches of the Cape Cod Ship Canal, Mass., 864; Merrimac River, Mass., between Newburyport and Haverhill, 865; Manchester Harbor, Mass., with a view of securing 8-foot depth, 866; Manchester Harbor, Mass., for 6-foot depth, 869; Marblehead Harbor, Mass., for sea wall, 870; Lynn Harbor, Mass., 872; Weymouth (Back) River, Mass., 873; Neponset River, Mass., 875; harbor at Plymouth, Mass., 877; Provincetown Harbor, Mass., for dike to protect the same, 878.

Harbor Lines.—Charles River, at Cambridge, Mass., 881.

APPENDIX C.

REPORT OF MAJ. D. W. LOCKWOOD, CORPS OF ENGINEERS.

Improvements.—Harbor of refuge at Hyannis, Mass., 884; harbor of refuge at Nantucket, Mass., 886; Marthas Vineyard inner harbor at Edgartown, Mass., 890; Vineyard Haven Harbor, Mass., 892; Woods Hole Channel, Mass., 894; New Bedford Harbor, Mass., 897; Canapitsit Channel, Mass., 900; Taunton River, Mass., 901; Sakonnet River, R. I., 904; Pawtucket River, R. I., 905; Providence River and Narragansett Bay, R. I., 908; Green Jacket Shoal, Providence River, R. I., 911; Wickford Harbor, R. I., 913; Newport Harbor, R. I., 915; harbor of refuge at Point Judith, R. I., 918; entrance to Point Judith Pond, R. I., 921; harbor of refuge at Block Island, R. I., 922; Great Salt Pond, Block Island, R. I., 925; removing sunken vessels or craft obstructing or endangering navigation, 927.

Examination and Surveys.—For obtaining a channel through Conanicut Island, Narragansett Bay, R. I., 928; channel in New Bedford Harbor, Mass., leading to the bridge between that city and Fairhaven, 930; Mount Hope Bay and Fall River Harbor, Mass., 931; Sakonnet Point, R. I., 934; easterly breakwater to shore, Point Judith, at Point Judith harbor of refuge, R. I., 937.

APPENDIX D.

REPORT OF MAJ. SMITH S. LEACH, CORPS OF ENGINEERS.

IMPROVEMENTS.—Pawcatuck River, R. I. and Conn., 940; harbor of refuge at Stonington, Conn., 942; Mystic River, Conn., 944; Thames River, Conn., 946; Connecticut River below Hartford, Conn., 948; harbor of refuge at Duck Island, Conn., 951; New Haven Harbor, Conn., 953; breakwaters at New Haven, Conn., 955; Housatonic River, Conn., 956; Bridgeport Harbor, Conn., 958; Saugatuck River and Westport Harbor, Conn., 961; Norwalk Harbor, Conn., 963; Five Mile River Harbor, Conn., 965; Stamford Harbor, Conn., 967; harbor at Coscob and Mianus River, Conn., 969; Greenwich Harbor, Conn., 970.

SURVEYS.—Niantic Harbor, Conn., 972; New Haven Harbor, Conn., 974; Housatonic River, Conn., 979; Southport Harbor, Conn., 986.

HARBOR LINES.—Bridgeport, Conn., 988.

APPENDIX E.

REPORT UPON WORKS IN THE CHARGE OF COL. G. L. GILLESPIE AND LIEUT. COL. WILLIAM LUDLOW, CORPS OF ENGINEERS.

IMPROVEMENTS.—Hudson River, N. Y., 996; harbor at Saugerties, N. Y., 1010; harbor at Rondout, N. Y., 1013; harbor at Peekskill, N. Y., 1016; Harlem River, N. Y., 1019; East River and Hell Gate, N. Y., 1026; New York Harbor, N. Y., 1031; removing sunken vessels or craft obstructing or endangering navigation, 1039.

EXAMINATIONS AND SURVEY.—Catskill Creek, N. Y., 1041; Nyack Harbor, N. Y., 1014; Wallabout Channel, N. Y., 1047; Coney Island Channel, N. Y., 1048; Coney Island Creek, N. Y., 1050; New York Harbor, N. Y., from the Narrows to the sea, with a view of obtaining a depth of 35 feet at mean low-water mark, 1053.

HARBOR LINES.—Hudson River from West Twenty-third street to West Eighty-first street, New York City, 1067; Hudson River, both sides, from Battery Place to West Twenty-third street, New York City, and from Morris Canal Basin to abreast Bulls Ferry, N. J., 1070; Ellis Island, New York Harbor, 1075; Harlem River and Spuyten Duyvil Creek, New York City, 1077; East River, near the foot of East Eighty-eighth street, New York City, 1081.

APPENDIX F.

REPORT OF MAJ. H. M. ADAMS, CORPS OF ENGINEERS.

IMPROVEMENTS.—Port Chester Harbor, N. Y., 1084; Mamaroneck Harbor, N. Y., 1087; East Chester Creek, N. Y., 1089; Bronx River, N.Y., 1093; Mattituck Harbor, N. Y., 1095; Port Jefferson Harbor, N. Y., 1097; Huntington Harbor, N. Y., 1100; Glencove Harbor, N. Y., 1103; Flushing Bay, N. Y., 1106; Patchogue River, N. Y., 1108; Browns Creek, Sayville, Long Island, N. Y., 1111; Canarsie Bay, N. Y., 1114; Bay Ridge Channel, the triangular area between Bay Ridge and Red Hook channels, and Red Hook and Buttermilk channels, in the harbor of New York, 1117; Gowanus Creek Channel, N. Y., 1122; Newtown Creek, N. Y., 1125; Passaic River, N. J., 1128; channel between Staten Island and New Jersey, 1130; Elizabeth River, N. J., 1134; Raritan River, N. J., 1136; South River, N. J., 1139; Raritan Bay, N. J., 1142; Mattawan Creek, N. J., 1145; harbor at Keyport, N. J., 1147; Shoal Harbor and Compton Creek, N. J., 1150; Shrewsbury River, N. J., 1152; removing sunken vessels or craft obstructing or endangering navigation, 1156.

EXAMINATIONS AND SURVEYS.—For channel connecting Flushing Bay and Newtown Creek, N. Y., 1159; Roslyn Harbor, N. Y., 1161; harbor at Oyster Bay, N. Y., 1163; Lloyds Harbor, with a view to its connection with Cold Spring Bay, N. Y., 1165; Northport Harbor, N. Y., 1167; Smithtown Harbor, N. Y., 1168; channels to Far Rockaway and Inwood, N. Y., 1170; Babylon Creek, N. Y., 1172; East Chester Creek, N. Y., 1175; Bay Ridge Channel, the triangular area between Bay Ridge and Red Hook channels, and Red Hook and Buttermilk channels, New York Harbor, for channels 30 and 35 feet deep at mean low water, 1177; Gowanus Creek, N. Y., 1180; channel between the Battery and Governors Island, N. Y., 1182; Elizabeth River, N. J., 1185; Rahway River, N. J., 1187.

PART II.

APPENDIX G.

REPORT OF MAJ. C. W. RAYMOND, CORPS OF ENGINEERS.

IMPROVEMENTS.—Delaware River, N. J. and Pa., 1192; harbor between Philadelphia, Pa., and Camden, N. J., 1205; Schuylkill River, Pa., 1211; ice harbor at Marcushook, Pa., iron pier in Delaware Bay, near Lewes, Del., 1213; Delaware Breakwater, Del., 1214; harbor of refuge, Delaware Bay, Del., 1216; Rancocas River, N. J., 1219; Alloway Creek, N. J., 1220; Dennis Creek, N. J., 1222; Cooper Creek, N. J., 1223; Goshen Creek, N. J., 1225; removing sunken vessels or craft obstructing or endangering navigation, 1227.

EXAMINATIONS AND SURVEY.—Barnegat Bay, N. J., between Mantoling (Mantoloking) and Bay Head, 1229; Tuckerton Creek, N. J., and flats at mouth thereof, 1230; Wading River, N. J., 1233; Beach Thoroughfare, N. J., at and near the meeting of tides from Absecon and Egg Harbor Inlet, 1235; Oldmans Creek, N. J., 1238; Dividing Creek, N. J., 1242; Salem River, N. J., 1245.

APPENDIX H.

REPORT OF WM. F. SMITH, UNITED STATES AGENT, MAJOR OF ENGINEERS, UNITED STATES ARMY, RETIRED.

IMPROVEMENTS.—Wilmington Harbor, Del., 1250; Nanticoke River, Del. and Md., 1260; Appoquinimink River, Del., 1261; Smyrna River, Del., 1263; Murderkill River, Del., 1266; Mispillion River, Del., 1268; Broadkiln River, Del., inland waterway from Chincoteague Bay, Va., to Delaware Bay, at or near Lewes, Del., 1270; Susquehanna River, above and below Havre de Grace, Md., 1272; Chester River, Md., from Crumpton to Jones Landing, 1273; Choptank River, Md., 1275; La Trappe River, Md., 1276; Warwick River, Md., 1277; Broad Creek River, Del., 1278; Wicomico River, Md., 1280; Manokin River, Md., 1282; Pocomoke River, Md., below Snow Hill, 1284; Queenstown Harbor, Md., 1286; Rockhall Harbor and inner harbor at Rockhall, Md., 1287; removing sunken vessels or craft obstructing or endangering navigation, 1288.

EXAMINATIONS AND SURVEYS.—St. Jones River, Del., 1290; Mispillion River, Del., 1291; Cedar Creek, Del., 1293; La Trappe River, Md., 1295; Cambridge Harbor, Md., 1296.

APPENDIX I.

REPORT OF COL. PETER C. HAINS, CORPS OF ENGINEERS.

IMPROVEMENTS.—Patapsco River and channel to Baltimore, Md., 1299; channel to Curtis Bay, in Patapsco River, Baltimore Harbor, Md., 1306; harbor of southwest Baltimore (Spring Garden), Md., removing sunken vessels or craft obstructing or endangering navigation, 1307.

SURVEYS.—Baltimore Harbor, Md., with a view to securing a channel 30 feet in depth, 1308; Annapolis Harbor, Md., 1309.

APPENDIX J.

REPORT OF LIEUT. COL. CHAS. J. ALLEN, CORPS OF ENGINEERS.

IMPROVEMENTS.—Potomac River at Washington, D. C., 1313; Occoquan Creek, Va., 1321; Aquia Creek, Va., 1324; Nomini Creek, Va., 1326; Lower Machodoc Creek, Va., 1329; Rappahannock River, Va., 1331; Urbana Creek, Va., 1335; York River, Va., 1337; Mattaponi River, Va., 1342; Pamunkey River, Va., 1344; James River, Va., 1346; protection of Jamestown Island, Va., 1349.

SURVEY.—Chapel Point Harbor, Md., 1350.

APPENDIX K.

REPORT OF CAPT. THOS. L. CASEY, CORPS OF ENGINEERS.

IMPROVEMENTS.—Harbor at Norfolk and its approaches, Va., 1353; Western Branch of Elizabeth River, Va., 1365; Nansemond River, Va., 1367; Appomattox River, Va., 1369; harbor at Cape Charles City, Va., 1370; Nandua Creek, Va., 1373; inland water route from Norfolk, Va., to Albemarle Sound, N. C., through Currituck Sound, 1374; North Landing River, Va. and N. C., 1376; Roanoke River, N. C., 1377; Pasquotank River, N. C., 1378; removing sunken vessels or craft obstructing or endangering navigation, 1379.

EXAMINATIONS.—Cashie River, N. C., 1381; Potecasi Creek, N. C., 1383.

APPENDIX L.

REPORT UPON WORKS IN THE CHARGE OF LIEUT. COL. D. P. HEAP AND CAPT. W. E. CRAIGHILL, CORPS OF ENGINEERS.

IMPROVEMENTS.—Ocracoke Inlet, N. C., 1385; Fishing Creek, N. C., 1387; Pamlico and Tar rivers, N. C., 1388; Contentnia Creek, N. C., 1389; Trent River, N. C., 1391; Neuse River, N. C., 1393; inland waterway between Newbern and Beaufort, N. C., via Clubfoot, Harlowe, and Newport rivers, 1395; harbor at Beaufort, N. C., 1396; inland waterway between Beaufort Harbor and New River, N. C., 1398; New River, N. C., 1399; North East River, N. C., 1400; Black River, N. C., 1402; Cape Fear River above Wilmington, N. C., 1404; Cape Fear River, N. C., at and below Wilmington, 1406; Lockwoods Folly River, N. C., 1417.

EXAMINATION AND SURVEYS.—Bogue Inlet, N. C., 1418; Ocracoke Inlet, N. C., 1423; Pamlico River, N. C., and harbor at Washington, 1425; Neuse River, N. C., at and below Newbern, 1427; Cape Lookout harbor of refuge, N. C., 1430; Town Creek, Brunswick County, N. C., 1434.

APPENDIX M.

REPORT OF CAPT. FREDERIC V. ABBOT, CORPS OF ENGINEERS.

IMPROVEMENTS.—Waccamaw River, N. C. and S. C., 1439; Lumber River, N. C. and S. C., 1442; Little Pedee River, S. C., 1444; Great Pedee River, S. C., 1447; Mingo Creek, S. C., 1450; Winyah Bay, S. C., 1452; Santee River, S. C., 1458; Wateree River, S. C., 1465; Congaree River, S. C., 1468; harbor at Charleston, including Sullivan Island and Mount Pleasant shore, S. C., 1471; Wappoo Cut, S. C., 1479; Beaufort River, S. C., 1482.

HARBOR LINES.—Ashley and Cooper rivers, at Charleston Harbor, S. C., 1487.

APPENDIX N.

REPORT OF CAPT. O. M. CARTER, CORPS OF ENGINEERS.

IMPROVEMENTS.—Savannah Harbor, Ga., 1493; Savannah River, between Savannah and Augusta, Ga., 1503; Savannah River, above Augusta, Ga., 1506; Darien Harbor, Ga., 1508; Altamaha River, Ga., 1513; Oconee River, Ga., 1516; Ocmulgee River, Ga., 1519; Brunswick Harbor, Ga., 1521; Cumberland Sound, Ga., 1526; inside water route between Savannah, Ga., and Fernandina, Fla., 1535; removing sunken vessels or craft obstructing or endangering navigation, 1538.

SURVEY.—Doboy Bar, Ga., 1538.

APPENDIX O.

REPORT OF LIEUT. COL. W. H. H. BENYAURD, CORPS OF ENGINEERS.

IMPROVEMENTS.—St. Johns River, Fla., 1547; Volusia Bar, Fla., 1550; Ocklawaha River, Fla., 1552; St. Augustine Harbor, Fla., 1553; Indian River, Negro Cut, and Jupiter Inlet, Fla., 1554; northwest entrance, Key West Harbor, Fla., 1555; Caloosahatchee River, Fla., 1557; Charlotte Harbor and Pease Creek, Fla., 1559; Sarasota Bay, Fla., 1560; Manatee River, Fla., 1562; Withlacoochee River, Fla., Suwanee River, Fla., 1564; removing sunken vessels or craft obstructing or endangering navigation, 1566.

EXAMINATIONS AND SURVEYS.—Jupiter Inlet, Fla., 1568; Orange River, Fla., to its confluence with the Caloosahatchee River, and thence to the Gulf of Mexico, 1569; inside passage from Punta Rasa to Charlotte Harbor, Fla., 1572; Hillsboro Bay, Fla., from Tampa Bay through Hillsboro Bay and River to the city of Tampa, 1574; Clearwater Harbor, Fla., 1578; Crystal River, Fla., 1580; harbor at Cedar Keys, Fla., 1583; Palmbeach, Fla., 1585; Biscayne Bay, Fla., 1588; Tampa Bay, 1596.

APPENDIX P.

REPORT OF MAJ. F. A. MAHAN, CORPS OF ENGINEERS.

IMPROVEMENTS.—Carrabelle Bar and Harbor, Fla., 1603; Apalachicola Bay, Fla., 1605; Apalachicola River, the Cut-off, and lower Chipola River, Fla., 1609; Flint River, Ga., 1612; Chattahoochee River, Ga. and Ala., 1616; Choctawhatchee River, Fla. and Ala., 1621; Pensacola Harbor, Fla., 1625; Escambia and Conecuh rivers, Fla. and Ala., 1631; Alabama River, Ala., 1633; Coosa River, Ga. and Ala., 1642; operating and care of canals and other works of navigation on Coosa River, Ga. and Ala., 1654.

SURVEY.—Apalachicola Bay, Fla., 1655.

APPENDIX Q.

REPORT OF MAJ. WM. T. ROSSELL, CORPS OF ENGINEERS.

IMPROVEMENTS.—Harbor at Mobile, Ala., 1662; Black Warrior River, Ala., from Tuscaloosa to Daniels Creek, 1667; operating and care of locks and dams on Black Warrior River, Ala., 1675; Warrior and Tombigbee rivers, Ala. and Miss., 1678; Noxubee River, Miss., 1691; Pascagoula River, Miss., 1692; Chickasahay River, Miss., 1695; Leaf River, Miss., 1697; Pearl River below Jackson, Miss., 1698; Pearl River between Carthage and Jackson, Miss., 1700; Pearl River between Edinburg and Carthage, Miss., 1702; Bogue Chitto, La., 1703; canal from Birmingham, Ala., to the Warrior River, 1704.

EXAMINATIONS AND SURVEYS.—Canal to connect Black Warrior River and Five Mile Creek, Ala., via Valley Creek, 1704; Ship Island Pass, Miss., for channel between Gulf of Mexico and Ship Island Harbor, and for dredging channel to connect Ship Island Harbor with Gulfport, 1708; Horn Island Pass, Miss., and the passage leading from said pass to the anchorage inside Horn Island, 1716; Pascagoula River, Miss., and up Dog River 3 miles, 1718; Ship Island Harbor, Mississippi Sound, for deep-water channel to the mainland, 1722; channel at mouth of Pearl River, Miss., 1727.

APPENDIX R.

REPORT OF MAJ. JAMES B. QUINN, CORPS OF ENGINEERS.

INSPECTION of the improvement of the South Pass of the Mississippi River, 1731.

APPENDIX S.

REPORT OF MAJ. JAMES B. QUINN, CORPS OF ENGINEERS.

IMPROVEMENTS.—Chefuncte River and Bogue Falia, La., 1751; Tickfaw River and tributaries, La., 1753; Amite River and Bayou Manchac, La., 1756; Bayou Lafourche, La., 1757; Bayou Plaquemine, Grand River, and Pigeon bayous, La., 1759; Bayou Courtableau, La., 1762; Bayou Teche, La., 1764; channel, bay, and passes of Bayou Vermilion, La., 1766; Mermentau River and tributaries, La., 1767; mouth and passes of Calcasieu River, La., 1768; harbor at Sabine Pass, Tex., 1771; Sabine River, Tex., 1773; Neches River, Tex., 1775; closing crevasse in Pass a Loutre, Mississippi River, removing sunken vessels or craft obstructing or endangering navigation, 1776.

EXAMINATIONS AND SURVEYS.—Homochitto River, Miss., 1777; channel through Atchafalaya Bay, La., 1779; Bayou Grossetete, La., 1781; Bayou Teche from St. Martinville to Port Barre, La., 1783; Sabine Lake, Tex., for ship channel, 1789.

APPENDIX T.

REPORT OF MAJ. A. M. MILLER, CORPS OF ENGINEERS.

IMPROVEMENTS.—Galveston Harbor, Tex., 1793; ship channel in Galveston Bay, Tex., 1803; channel in West Galveston Bay, Tex., 1804; Trinity River, Tex., 1805; Buffalo Bayou, Tex., 1806; Brazos River, Tex., operating and care of Morgan Canal, Tex., 1808.

EXAMINATION AND SURVEY.—Channel between Brazos River and Galveston Bay, Tex., 1809; for further determining the causes of the erosion of the easterly end of Galveston Island, Tex., 1813; character and value of improvements made at the mouth of Brazos River by the Brazos River Channel and Dock Company, 1815.

PART III.

APPENDIX U.

REPORT OF MAJ. J. H. WILLARD, CORPS OF ENGINEERS.

IMPROVEMENTS.—Red River, La. and Ark., 1877; Red River above Fulton, Ark., 1895; Cypress Bayou, Tex. and La., 1896; Ouachita and Black rivers, Ark. and La., 1904; Bayou Bartholomew, La. and Ark., 1914; Bœuf River, La., 1917; Tensas River and Bayou Maçon, La., 1920; Yazoo River, Miss., 1922; mouth of Yazoo River and harbor at Vicksburg, Miss., 1927; Tallahatchie River, Miss., 1932; Big Sunflower River, Miss., 1935; water gauges on the Mississippi River and its principal tributaries, 1936.

EXAMINATION.—Coldwater River, Miss., 1943.

APPENDIX V.

REPORT OF CAPT. WM. L. SIBERT, CORPS OF ENGINEERS.

IMPROVEMENTS.—Removing obstructions in Arkansas River, Ark. and Kans., 1949; improving Arkansas River, Ark., 1952; White River, Ark., 1971; Black River, Ark. and Mo., 1975; Current River, Ark. and Mo., 1978; St. Francis River, Ark., 1980; St. Francis River, Mo., 1982.

EXAMINATION AND SURVEYS.—Neosho River, Kans., 1984; Arkansas River at Little Rock, Vanburen, and Fort Smith, Ark., 1989; Arkansas River at Pinebluff, Ark., 1990; White River from Batesville to Buffalo Shoals, Ark., 1992; Buffalo Fork of White River, Ark., 1994; St. Francis River, Ark., and Mo., from the Sunk Lands to Poplin, Mo., 1999.

APPENDIX W.

REPORT OF MAJ. THOS. H. HANDBURY, CORPS OF ENGINEERS.

IMPROVEMENTS.—Removing snags and wrecks from Mississippi River, 2001; Mississippi River between Ohio and Missouri rivers, 2012; harbor at St. Louis, Mo., 2046; preventing the Mississippi River from breaking through into the Cache River at or near a point known as Beach Ridge, a few miles above Cairo, Ill., 2047.

APPENDIX X.

REPORT OF LIEUT. COL. W. R. KING, CORPS OF ENGINEERS.

IMPROVEMENTS.—Operating snag boats and dredge boats on Upper Mississippi River, 2049; Mississippi River between mouth of Missouri River and Minneapolis, 2059; operation and care of Des Moines Rapids Canal and Dry Dock, 2104; operating and care of Galena River improvement, Ill., 2109; Mississippi River between St. Paul and Minneapolis—construction of Lock and Dam No. 2, 2110.

SURVEYS.—East bank of Mississippi River between Oquawka and Dallas City, Ill., 2111; east side of Mississippi River, between Drurys Landing and New Boston, Ill., 2114; La Crosse Harbor, Wis., 2116; west side of Mississippi River, commencing near Lagrange and running along the bank of the river to near the railroad bridge over Mississippi River above Hannibal, Mo., 2119; Egyptian Levee along the south bank of Des Moines River to or near Mississippi River at Alexandria, Mo., thence along the west bank of said river to terminus of said Egyptian Levee, 2124; west side of Mississippi River from the bluff above the city of Fort Madison to the mouth of Skunk River, Iowa, 2130; west bank of Mississippi River from mouth of Iowa River to Muscatine, Iowa, 2133.

APPENDIX Y.

REPORT OF LIEUT. COL. W. A. JONES, CORPS OF ENGINEERS.

IMPROVEMENTS.—Construction of reservoirs at head waters of Mississippi River, 2137; operating and care of reservoirs at head waters of Mississippi River, 2142; Chippewa River, including Yellow Banks, Wis., 2152; St. Croix River, Wis. and Minn., 2154; Minnesota River, Minn., 2156; Red River of the North, Minn. and N. Dak., 2158; gauging Mississippi River at or near St. Paul, Minn., 2164.

EXAMINATIONS.—Mille Lacs Lake, Minn., for reservoir, 2170; Otter Tail Lake and Otter Tail River, Minn., for reservoir, 2172; Red Lake and Red Lake River, Minn., for reservoir, 2173.

APPENDIX Z.

REPORT UPON WORKS IN THE CHARGE OF LIEUT. COL. W. A. JONES AND CAPT. J. C. SANFORD, CORPS OF ENGINEERS.

IMPROVEMENTS.—Missouri River, between Stubbs Ferry, Mont., and the lower limits of Sioux City, Iowa, 2177; improving Upper Missouri River by snagging, 2208; Yellowstone River, Mont. and N. Dak., 2211.

APPENDIX A A.

REPORT OF CAPT. JOHN BIDDLE, CORPS OF ENGINEERS.

IMPROVEMENTS.—Obion River, Tenn., 2215, 2219; Forked Deer River, Tenn., 2217; Cumberland River, Tenn. and Ky., 2220.

SURVEYS.—North Fork of Forked Deer River, Tenn., main stream, and Obion River, with a view to improving navigation from Dyersburg to the Mississippi River, 2234; mouth of Cumberland River, 2242.

APPENDIX B B.

REPORT OF CAPT. DAN C. KINGMAN, CORPS OF ENGINEERS.

IMPROVEMENTS.—Tennessee River system, 2247; Tennessee River, 2251; operating and care of Muscle Shoals Canal, Tennessee River, 2296; French Broad and Little Pigeon rivers, Tenn., 2308; Clinch River, Tenn., 2311.

SURVEYS.—Mouth of Tennessee River, Ky., 2314; Emory River, Tenn., 2316.

APPENDIX C C.

REPORT OF MAJ. W. H. HEUER, CORPS OF ENGINEERS.

IMPROVEMENTS.—Ohio River, 2325; operating snag boat on Ohio River, 2349; operating and care of Davis Island Dam, Ohio River, near Pittsburg, Pa., 2354; Movable Dams Nos. 2, 3, 4, 5, and 6, Ohio River, 2358; Muskingum River, Ohio, 2363; operating and care of locks and dams on Muskingum River, Ohio, 2364; observations on Muskingum River, Ohio, 2378.

EXAMINATION.—Ohio River from Marietta, Ohio, to its mouth, 2379.

APPENDIX D D.

REPORT UPON WORKS IN THE CHARGE OF MAJ. CHAS. F. POWELL AND MAJ. R. L. HOXIE, CORPS OF ENGINEERS.

IMPROVEMENTS.—Monongahela River, W. Va., and Pa., 2383; operating and care of Locks and Dams Nos. 8 and 9, Monongahela River, 2409; purchase of Locks and Dams Nos. 6 and 7, Monongahela River, condemnation of all the property and appurtenances of the Monongahela Navigation Company, 2411; Allegheny River, Pa., 2424; construction of locks and dams at Herr Island, above the head of Six Mile Island, and at Springdale, Allegheny River, 2428.

APPENDIX E E.

REPORT OF CAPT. J. G. WARREN, CORPS OF ENGINEERS.

IMPROVEMENTS.—Falls of Ohio River at Louisville, Ky., and Indiana Chute, Falls of Ohio River, 2441; operating and care of Louisville and Portland Canal, Ky., 2444; Wabash River, Ind. and Ill., 2452; operating and care of lock and dam at Grand Rapids, Wabash River, 2455; White River, Ind., Tradewater River, Ky., 2456; reconstruction of Lock No. 2, Green River, at Rumsey, Ky., 2457; Green River, Ky., above mouth of Big Barren River (Lock No. 5), 2459; operating and care of locks and dams on Green and Barren rivers, Ky., 2462; Rough River, Ky., 2471.

EXAMINATION AND SURVEYS.—Treadwater (Tradewater) River, Ky., 2476; White River, Ind., 2483; Green River, Ky., at or near its mouth, for new lock and dam, 2504.

APPENDIX F F.

REPORT OF MAJ. JAMES F. GREGORY, CORPS OF ENGINEERS.

IMPROVEMENTS.—Kentucky River, Ky., 2513; operating and keeping in repair the six locks and dams on Kentucky River, Ky., 2519; Tug Fork of Big Sandy River, W. Va. and Ky., 2528; Levisa Fork, of Big Sandy River, Ky., 2529; Big Sandy River, W. Va. and Ky., 2530; Guyandotte River, W. Va., 2562; New River, Va. and W. Va., 2563; Gauley River, W. Va., 2564; Elk River, W. Va., 2565; Great Kanawha River, W. Va., 2566; operating and care of locks and dams on Great Kanawha River, W. Va., 2575; Little Kanawha River, W. Va., operating and keeping in repair the lock on Little Kanawha River, 2582.

APPENDIX G G.

REPORT OF MAJ. CLINTON B. SEARS, CORPS OF ENGINEERS.

IMPROVEMENTS.—Harbor at Grand Marais, Minn., 2585; harbor at Agate Bay, Minn., 2588; harbor at Duluth, Minn. and Superior, Wis., 2592; harbor at Ashland, Wis., 2603; harbor at Ontonagon, Mich., 2606; improvement and operating and care of waterway from Keweenaw Bay to Lake Superior, Mich., 2608; harbor at Marquette, Mich., 2615; harbor of refuge at Presque Ile Point, Marquette Bay, Mich., 2638; harbor of refuge at Grand Marais, Mich., 2640.

EXAMINATION.—Harbor at Portwing, Wis., 2643.

HARBOR LINES.—Superior and Allouez bays at Duluth and Superior Harbor, Minn. and Wis., 2647.

PART IV.

APPENDIX H H.

REPORT OF CAPT. GEO. A. ZINN, CORPS OF ENGINEERS.

IMPROVEMENTS.—Menominee Harbor, Mich. and Wis., 2650; Menominee River, Mich. and Wis., 2652; Oconto Harbor, Wis., 2653; Pensaukee Harbor, Wis., 2656; Green Bay Harbor, Wis., 2657; Sturgeon Bay and Lake Michigan Ship Canal, Wis., 2660; operating and care of Sturgeon Bay and Lake Michigan Ship Canal, Wis., 2666; Sturgeon Bay Canal harbor of refuge, Wis., 2671; Ahnapee Harbor, Wis., 2672; Kewaunee Harbor, Wis., 2675; Two Rivers Harbor, Wis., 2678; Manitowoc Harbor, Wis., 2681; Sheboygan Harbor, Wis., 2685; Port Washington Harbor, Wis., 2687; harbor of refuge at Milwaukee, Wis., 2689; Milwaukee Harbor, Wis., 2692; South Milwaukee Harbor, Wis., 2696; Racine Harbor, Wis., 2698; Kenosha Harbor, Wis., 2702; Waukegan Harbor, Ill., 2706; Fox River, Wis., 2709; operating and care of locks and dams on Fox River, Wis., 2719; removing sunken vessels or craft obstructing or endangering navigation, 2751.

SURVEYS.—Harbor at Menominee, Mich. and Wis., 2751; harbor at Ahnapee, Wis., 2755; Sheboygan Harbor, Wis., 2761; Milwaukee Harbor, Wis., 2765; harbor at Racine, Wis., 2768; harbor at Kenosha, Wis., 2772.

HARBOR LINES.—Kewaunee, Wis., 2785; Waukegan, Ill., 2786.

APPENDIX I I.

REPORT OF MAJ. W. L. MARSHALL, CORPS OF ENGINEERS.

IMPROVEMENTS.—Chicago Harbor, Ill., 2790; Chicago River, Ill., 2793; Calumet Harbor, Ill., 2801; Calumet River, Ill. and Ind., 2810; Illinois River, Ill., 2815; operating and care of Lagrange and Kampsville locks, Illinois River, and approaches thereto, 2822; Illinois and Mississippi Canal, Ill., 2825; operating and care of Illinois and Mississippi Canal—canal around lower rapids of Rock River at Milan, Ill., 2880; removing sunken vessels or craft obstructing or endangering navigation, 2881.

EXAMINATION AND SURVEY.—Upper Illinois River and lower Des Plaines River, Ill., with a view to extension of navigation from Illinois River to Lake Michigan at or near Chicago, 2882; Wolf Lake and River, Ill. and Ind., with reference to their navigation in connection with the waters of Lake Michigan, 2887.

APPENDIX J J.

REPORT UPON WORKS IN THE CHARGE OF LIEUT. COL. G. J. LYDECKER AND CAPT. C. McD. TOWNSEND, CORPS OF ENGINEERS.

IMPROVEMENTS.—Michigan City Harbor, Ind., 2895; St. Joseph Harbor, Mich., 2905; St. Joseph River, Mich., 2909; South Haven Harbor, Mich., 2910; Saugatuck Harbor, Mich., 2913; Kalamazoo River, Mich., 2915; Holland (Black Lake) Harbor, Mich., 2916; Grand Haven Harbor, Mich., 2918; Grand River, Mich., 2921; Muskegon Harbor, Mich., 2923; White Lake Harbor, Mich., 2926; Pentwater Harbor, Mich., 2928; Ludington Harbor, Mich., 2930; Manistee Harbor, Mich., 2933; harbor of refuge at Portage Lake, Manistee County, Mich., 2936; Frankfort Harbor, Mich., 2939; Charlevoix Harbor, Mich., 2942; Petoskey Harbor, Mich., 2944; removing sunken vessels or craft obstructing or endangering navigation, 2947.

SURVEYS.—South Haven Harbor, Mich., 2948; harbor of Holland (Black Lake), Mich., 2950; Ludington Harbor, Mich., 2951; Charlevoix Harbor, Mich., 2953.

APPENDIX K K.

REPORT OF LIEUT. COL. G. J. LYDECKER, CORPS OF ENGINEERS.

IMPROVEMENTS.—Ship channel connecting waters of the Great Lakes between Chicago, Duluth, and Buffalo, 2955; St. Marys River at the falls, Mich., 2963; operating and care of St. Marys Falls Canal, Mich., 2997; Hay Lake Channel, St. Marys River, Mich., 3006; Cheboygan Harbor, Mich., 3009; Alpena Harbor (Thunder Bay River), Mich., 3011; Saginaw River, Mich., 3012; Sebewaing River, Mich., 3014; harbor of refuge at Sand Beach, Lake Huron, Mich., 3015; improvement of St. Clair Flats Canal, Mich., 3018; operating and care of St. Clair Flats Canal, Mich., 3019; mouth of Black River, Mich., 3021; Black River at Port Huron, Mich., 3022; Pine River, Mich., 3024; Belle River, Mich., 3025; Clinton River, Mich., 3027; Detroit River, Mich., 3029; Rouge River, Mich., 3031; turning basin in Rouge River, Mich., 3032; removing sunken vessels or craft obstructing or endangering navigation, 3033.
EXAMINATION.—Huron River, Mich., 3034.

APPENDIX L L.

REPORT OF COL. JARED A. SMITH, CORPS OF ENGINEERS.

IMPROVEMENTS.—Monroe Harbor, Mich., 3037; Toledo Harbor, Ohio, 3040; Port Clinton Harbor, Ohio, 3049; Sandusky Harbor, Ohio, 3052; Huron Harbor, Ohio, 3061; Vermilion Harbor, Ohio, 3068; Black River (Lorain) Harbor, Ohio, 3072; Cleveland Harbor, Ohio, 3075; Fairport Harbor, Ohio, 3082; Ashtabula Harbor, Ohio, 3086; Conneaut Harbor, Ohio, 3090.
EXAMINATION.—Raisin River, Monroe County, Mich., 3094.

APPENDIX M M.

REPORT OF MAJ. THOMAS W. SYMONS, CORPS OF ENGINEERS.

IMPROVEMENTS.—Erie Harbor, Pa., 3097; harbor at Dunkirk, N. Y., 3103; Buffalo Harbor, N. Y., 3107; Tonawanda Harbor and Niagara River, N. Y., 3116; Niagara River from Tonawanda to Port Day, N. Y., 3123; Wilson Harbor, N. Y., 3126.
EXAMINATION AND SURVEYS.—For ship canal from the Great Lakes to the Hudson River, N. Y., 3128; Erie Harbor, Pa., 3237; Buffalo entrance to Erie Basin and Black Rock Harbor, N. Y., 3245; report on widening locks of Erie Canal, N. Y., 3250.
HARBOR LINES.—Bay of Presque Isle, Erie, Pa., 3265.

APPENDIX N N.

REPORT OF MAJ. W. S. STANTON, CORPS OF ENGINEERS.

IMPROVEMENTS.—Harbor at Charlotte, N. Y., 3269; harbor at Pultneyville, N. Y., 3272; harbor at Great Sodus Bay, N. Y., 3274; harbor at Little Sodus Bay, N. Y., 3276; harbor at Oswego, N. Y., 3278; harbor at Sacketts Harbor, N. Y., 3285; harbor at Cape Vincent, N. Y., 3286; shoals between Sister Islands and Crossover Light, and between Ogdensburg and the foot of Lake Ontario, St. Lawrence River, N. Y., 3290; harbor at Ogdensburg, N. Y., 3292; harbor at Burlington, Vt., 3296; channel between North and South Hero islands, Lake Champlain, Vt., Otter Creek, Vt., 3299; Narrows of Lake Champlain, N. Y. and Vt., 3302; removing sunken vessels or craft obstructing or endangering navigation, 3304.
EXAMINATIONS AND SURVEYS.—Mohawk River, N. Y., between Rome and the town of Schuyler, 3304; Black River, N. Y., to harbor at Dexter, 3306; harbor at Alexdria Bay, N. Y., 3312; Oak Orchard Harbor, N. Y., 3314; Missisquoi River, Vt., from Swanton to Lake Champlain, 3319; report upon widening locks of the Oswego Canal, N. Y., 3324.

APPENDIX O O.

REPORT OF COL. CHAS. R. SUTER, CORPS OF ENGINEERS.

IMPROVEMENT.—Oakland Harbor, Cal., 3327.

APPENDIX P P.

REPORT OF MAJ. CHAS. E. L. B. DAVIS, CORPS OF ENGINEERS.

IMPROVEMENTS.—San Luis Obispo Harbor, Cal., 3333; Wilmington Harbor, Cal., 3335; San Diego Harbor, Cal., 3337.

EXAMINATIONS AND SURVEYS.—Colorado River, Ariz., 3339; Suisun Creek, Cal., 3341; Alviso Creek, Cal., 3343; Redwood Creek, Cal., 3349; Mare Island Strait, Cal., 3352.

APPENDIX Q Q.

REPORT OF CAPT. CASSIUS E. GILLETTE, CORPS OF ENGINEERS.

IMPROVEMENTS.—San Joaquin River, Cal., 3357; Mokelumne River, Cal., 3359; Sacramento and Feather rivers, Cal., 3360; Napa River, Cal., 3364; Petaluma Creek, Cal., 3365; Humboldt Harbor and Bay, Cal., 3366.

EXAMINATIONS.—Napa River, Cal., 3374; Petaluma Creek, Cal., 3375; Humboldt Harbor, Cal., for dredging at Eureka, 3377.

APPENDIX R R.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

IMPROVEMENTS.—Port Orford Harbor, Oreg., 3379; mouth of Coquille River, Oreg., 3380; Coquille River, Oreg., between Coquille City and Myrtle Point, 3383; entrance to Coos Bay and Harbor, Oreg., 3384; dredging harbor at Coos Bay, Oreg., 3387; Coos River, Oreg., 3388; Umpqua River, Oreg., 3389; mouth of Siuslaw River, Oreg., 3391; Alsea River, Oreg., 3393; Yaquina Bay, Oreg., 3394; Nestugga River, Oreg., 3396; Tillamook Bay and Bar, Oreg., 3397; mouth of Columbia River, Oreg. and Wash., 3404; Columbia River below Tongue Point, Oreg., 3406; Columbia and Lower Willamette rivers below Portland, Oreg., 3407; Columbia River between Vancouver, Wash., and mouth of Willamette River, 3414; construction of canal at the Cascades, Columbia River, Oreg., 3416; operating and care of canal and locks at the Cascades, Columbia River, Oreg., 3423; Columbia River at Three Mile Rapids, and boat railway from the foot of The Dalles Rapids to the head of Celilo Falls, 3425; Willamette River above Portland, and Yamhill River, Oreg., 3429; gauging waters of Columbia River, Oreg. and Wash., 3432.

APPENDIX S S.

REPORT OF CAPT. HARRY TAYLOR, CORPS OF ENGINEERS.

IMPROVEMENTS.—Willapa River and Harbor, Wash., 3434; Grays Harbor and bar entrance, Wash., 3436; Chehalis River, Wash., 3437; Puget Sound and its tributary waters, 3438; harbor at Olympia, Wash., 3443; waterway connecting Puget Sound with lakes Union and Washington, 3445; Everett Harbor, Wash., 3447; Swinomish Slough, Wash., 3450; Columbia River from Rock Island Rapids to Foster Creek Rapids, Wash., 3455; Upper Columbia and Snake rivers, Oreg. and Wash., 3456; Cowlitz River, Wash., 3463; Clearwater River, Idaho, 3465; Kootenai River, Idaho, between Bonners Ferry and the international boundary line, 3467; Flathead River, Mont., 3468.

EXAMINATIONS AND SURVEYS.—North Fork of Lewis River, Wash., to head of navigation, or Etna, 3469; North River, Wash., 3472; Lewis River, Wash., from Columbia River to Lacenter, 3473; Bellingham Bay, from deep water to the mouth of Whatcom Creek, at New Whatcom, Wash., 3478; Kootenai River, Mont., for removal of obstructions above Jennings, 3482.

HARBOR LINES.—Olympia Harbor, Wash., 3484.

APPENDIX T T.

REPORT OF CAPT. D. D. GAILLARD, CORPS OF ENGINEERS.

PRELIMINARY examination of Portland Channel (canal), Alaska, 3487.

APPENDIX U U.

REPORT UPON THE SUPERVISION OF THE HARBOR OF NEW YORK, N. Y.—LIEUT. COMMANDER DANIEL DELEHANTY AND LIEUT. JOHN F. PARKER, U. S. N., SUPERVISORS 3499

PART V.

APPENDIX V V.

REPORT OF THE MISSISSIPPI RIVER COMMISSION.

G. L. Gillespie, colonel, Corps of Engineers, U. S. A., president; Amos Stickney, lieutenant-colonel, Corps of Engineers, U. S. A.; Thos. H. Handbury, major, Corps of Engineers, U. S. A.; Mr. Henry L. Marindin, assistant, U. S. Coast and Geodetic Survey; Mr. B. M. Harrod, Mr. Robert S. Taylor, and Mr. Henry Flad, *Commissioners.*

Annual Report for Fiscal Year ending June 30, 1897, 3505.

Appendix 1.—Paper by Lieutenant-Colonel Stickney on plan of bank protection for the Mississippi River, 3536.

Appendix 2.—Letter of Mr. H. N. Pharr, chief engineer St. Francis Levee Board, giving his views as to the lessons of the flood of 1897, 3543.

Appendix 3.—Letter of Mr. T. G. Dabney, chief engineer Yazoo-Mississippi Delta Levee district, giving his views as to the lessons of the flood of 1897, 3548.

Appendix 4.—Letter of Mr. William Starling, chief engineer Mississippi Levee district, giving his views as to the lessons of the flood of 1897, 3551.

Appendix 5.—Letter of Mr. Henry B. Richardson, chief State engineer, Louisiana, giving his views as to the lessons of the flood of 1897, 3558.

Appendix 6.—Letter of Mr. C. H. Purvis, engineer Cotton Belt Levee district, giving his views as to the lessons of the flood of 1897, 3562.

Appendix 7.—Report of Capt. H. E. Waterman, Corps of Engineers, secretary Mississippi River Commission, upon operations during the year ending May 25, 1897, 3563; (A) laws affecting the Mississippi River Commission, 3572; (B) specifications for hydraulic dredges *Epsilon* and *Zeta*, 3575; (C) report of Captain Waterman upon dredging operations on the Mississippi River between Cairo and Memphis during low-water season of 1896, 3588; (D) report of Assistant Engineer J. A. Ockerson on field work, office reduction and mapping, and on the construction, operation, care, and repair of dredges, 3620; (E) report of Assistant Engineer C. W. Sturtevant on location of dredge work, 3695.

Appendix 8.—Report of Capt. Graham D. Fitch, Corps of Engineers, upon operations in First and Second districts, 3696; report of Assistant Engineer A. J. Nolty on operations of construction parties at Plum Point Reach and New Madrid, Mo., 3711; report of Assistant Engineer William Gerig on work of improving harbor at Memphis, Tenn., and construction work at Helena, Ark., 3717, 3718; report of Assistant Engineer Charles Levasseur on operations at Nonconnah Rock, 3720.

Appendix 9.—Report of Lieut. (now captain) H. C. Newcomer, Corps of Engineers, upon operations in Third district, 3725; report of Assistant Engineer A. Hider on revetment work and plant, 3733; report of Assistant Engineer H. St. L. Coppée on levees in Arkansas above Greenville, Miss., 3742; report of Assistant Engineer E. C. Tollinger on levees in Arkansas and Mississippi below Greenville, Miss., 3747; report of Assistant Engineer J. D. Van Meter on levees in Mississippi above Greenville, Miss., 3750; report of Inspector L. Y. Kerr on levees in Mississippi below Greenville, 3752; tables of operations for high-water protection of levees, revetment work, 3753; labor statement of levee work, 3758; United States expenditures for levees, 3759.

Appendix 10.—Report of Capt. Geo. McC. Derby, Corps of Engineers, upon operations in Fourth district, 3769; (A) value of plant, (B) commercial statistics, New Orleans, La., 3794; (C) list of civilian engineers, (D) report of Assistant Engineer H. S. Douglas on harbors at Natchez, Miss., and Vidalia, La., 3795; (E) report of Assistant Engineer H. S. Douglas on New Orleans Harbor, La., 3797; (F) report of Assistant Engineer H. S. Douglas on repairs to plant, 3806; (G) report of Assistant Engineer A. F. Woolley, jr., on Atchafalaya and Red rivers, 3809; (H) report of Assistant Engineer A. F. Woolley, jr., on dredging Fords Crossing, 3811; (I) report of Assistant Engineer W. J. Hardee on levees above New Orleans, La., 3812; (J) report of Surveyor H. B. Watson on levees below New Orleans, La., 3823; (K) abstracts of proposals, 3829.

PART VI.

APPENDIX W W.

REPORT OF THE MISSOURI RIVER COMMISSION.

Amos Stickney, lieutenant-colonel, Corps of Engineers, U. S. A., president; W. H. Heuer, major, Corps of Engineers, U. S. A.; Thos. H. Handbury, major, Corps of Engineers, U. S. A.; Mr. G. C. Broadhead and Mr. R. S. Berlin, *Commissioners.*

Annual Report for Fiscal Year ending June 30, 1897, 3837.

Appendix A.—Annual report of Assistant Engineer F. B. Maltby on surveys, 3857.

Appendix B.—Annual report of Assistant Engineer A. H. Blaisdell on water gauges 3859.

Appendix C.—Annual report of Assistant Engineer A. H. Blaisdell on commercial statistics, 3860.

Appendix D.—Report of Capt. Hiram M. Chittenden, Corps of Engineers, secretary Missouri River Commission, on steamboat wrecks, 3870.

Appendix E.—Report of Assistant Engineer A. H. Blaisdell on bridges, 3893.

Appendixes F, G, and H.—Annual reports of Division Engineer Samuel H. Yonge on operations at the following localities: (F) vicinity of Omaha, Nebr., and Council Bluffs, Iowa, 3894; (G) vicinity of Nebraska City, Nebr., 3902; (H) Osage division of first reach, 3907.

Appendixes I and J.—Annual reports of Division Engineer S. Waters Fox on operations at the following localities: (I) Osage division of first reach, 3908; (J) Gasconade division, 3919.

Appendix K.—Annual report of Captain Chittenden on construction of Lock No. 1, Osage River, Mo., 3933.

Appendix L.—Report of Assistant Engineer James A. Seddon on filling and emptying locks, 3936.

Appendix M.—Report of Assistant Engineer F. B. Maltby on cement tests, 3941.

Appendix N.—Annual report of Assistant Engineer L. P. Butler on improvement of Gasconade River, 3943.

Project for construction of Lock and Dam No. 1 at Brennekes Shoal, Osage River, Mo., 3946.

APPENDIX X X.

REPORT OF THE CALIFORNIA DÉBRIS COMMISSION.

Chas. R. Suter, colonel, Corps of Engineers, U. S. A., president; Chas. E. L. B. Davis, major, Corps of Engineers, U. S. A., and Cassius E. Gillette, captain, Corps of Engineers, U. S. A., *Commissioners.*

Annual Report for Fiscal Year ending June 30, 1897, 3961.

Appendix A.—Synopsis of applications for authority to mine, with action taken thereon, 3964.

Appendix B.—Act of the legislature of California, approved March 17, 1897, appropriating funds to be used in conjunction with appropriations made by the United States, 3979.

APPENDIX Y Y.

OCCUPANCY OF AND INJURY TO PUBLIC WORKS BY CORPORATIONS AND INDIVIDUALS.

(1) Report of Lieut. Col. Chas. J. Allen, Corps of Engineers, 3981; (2) report of Maj. J. H. Willard, Corps of Engineers, (3) report of Capt. Dan C. Kingman, Corps of Engineers, 3982; (4) report of Maj. James F. Gregory, Corps of Engineers, 3983; (5) report of Capt. Geo. A. Zinn, Corps of Engineers, 3984; (6) report of Lieut. Col. G. J. Lydecker, Corps of Engineers, (7) report of Maj. W. S. Stanton, Corps of Engineers, 3985.

MISCELLANEOUS.

APPENDIX Z Z.

REPORT OF LIEUT. COL. CHAS. J. ALLEN, CORPS OF ENGINEERS.

Repair of the Aqueduct Bridge across Potomac River at Washington, D. C., 3987.

APPENDIX A A A.

REPORT UPON WORKS IN THE CHARGE OF LIEUT. COL. CHAS. J. ALLEN AND CAPT. D. D. GAILLARD, CORPS OF ENGINEERS.

Washington Aqueduct, 3991; increasing the water supply of Washington, D. C., 4018.

APPENDIX B B B.

REPORT UPON WORK IN THE CHARGE OF COL. (NOW BRIG. GEN.) JOHN M. WILSON, CORPS OF ENGINEERS, COL. THEO. A. BINGHAM, U. S. A., AND LIEUT. JOHN. S. SEWELL, CORPS OF ENGINEERS.

Improvement and care of public buildings and grounds in the District of Columbia, 4025; Washington Monument, 4032.

APPENDIX C C C.

SURVEY OF NORTHERN AND NORTHWESTERN LAKES.

Appendix 1.—Report of Lieut. Col. G. J. Lydecker, Corps of Engineers, upon surveys and issuing of charts, 4069; (A) report of Assistant Engineer E. E. Haskell on resurvey of St. Marys River, 4073; (B) report of Assistant Engineer E. E. Haskell upon discharge measurements at Sault Ste. Marie, 4092; (C) report of Assistant Engineer Thomas Russell upon field work across the upper peninsula of Michigan, 4104; (D) report of Assistant Engineer H. von Schon on resurvey of St. Marys River, 4115; (E) report of Assistant Engineer H. von Schon on completed extension of precise levels, St. Marys River, 4118.

Appendix 2.—Report of Maj. W. S. Stanton, Corps of Engineers, on preservation of bench marks along the Erie Canal, 4122.

Appendix 3.—Report of Col. Jared A. Smith, Corps of Engineers, on examination of shoal in Lake Erie, 4123; report of Assistant Engineer Wm. T. Blunt, 4125.

Appendix 4.—Water-level observations, 4127.

APPENDIX D D D.

EXPLORATIONS AND SURVEYS IN MILITARY DEPARTMENTS.

Report of Maj. W. L. Marshall, Corps of Engineers, on operations in the Department of the Missouri, 4131; report of Maj. Thomas H. Barry, assistant adjutant-general, on operations in the Department of the Columbia, 4132; report of Lieut. J. D. Miley, Fifth Artillery, on operations in the Department of California, 4133; report of Lieut. John L. Sehon, Twentieth Infantry, A. D. C., on operations in the Department of the Colorado, 4134.

APPENDIX E E E.

LAWS FOR PROTECTION OF NAVIGABLE WATERS 4137

LAWS AFFECTING THE CORPS OF ENGINEERS, FIFTY-FOURTH CONGRESS, SECOND SESSION, AND FIFTY-FIFTH CONGRESS, FIRST SESSION, 1896-97 .... 4151, 4197

APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS,

UNITED STATES ARMY.

(CONTINUED.)

APPENDIX V V.

ANNUAL REPORT OF THE MISSISSIPPI RIVER COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1897.

ARMY BUILDING,
New York City, July 1, 1897.

SIR: The Mississippi River Commission begs leave to submit its annual report for the fiscal year ending June 30, 1897.

APPROPRIATIONS AND ALLOTMENTS.

The appropriations and allotments for the fiscal year ending June 30, 1897, were as follows:

Joint resolution of Congress (Public—No. 6) approved March 31, 1897	$250,000
Allotted as follows:	
Upper Yazoo Levee district	20,000
Lower Yazoo Levee district	45,000
Upper Tensas Levee district	40,000
Lower Tensas Levee district	35,000
Fourth district below Red River	60,000
Preservation of works, Fourth district	20,000
Lower St. Francis Levee district	10,000
White River Levee district	5,000
Unallotted	15,000
Total	250,000
Sundry civil act approved June 4, 1897	2,933,333

The Commission has had six sessions during the year. During two of these—one extending from November 5 to 15, 1896; the other from March 24 to 31, 1897—inspections were made of the river from St. Louis to New Orleans. The first of these inspections was extended to the Head of the Passes. The following committee meetings were also held: Three by the committee on dredges and one by the committee on levees.

The changes in the personnel of the Commission since the last annual report have been the loss of Henry L. Whiting, United States Coast and Geodetic Survey, by his death, which occurred February 4, 1897. and the assignment of H. L. Marindin, United States Coast and Geodetic Survey, on March 22, 1897, to the position thus made vacant.

OPERATIONS IN CHARGE OF THE SECRETARY OF THE COMMISSION.

Survey of the Mississippi River.—The field operations of this survey were limited during the year to topography, contouring, and hydrography only. The secondary triangulation having previously been extended to Minneapolis, the topography and hydrography were continued from near Arnolds Landing to Brownsville, Minn. This work was commenced May 29 and closed November 6, 1896. During this time 160 miles of river was covered.

Field work was resumed again near Brownsville May 20, 1897. The river being at high stages, work to the end of the fiscal year has been confined to the survey of ~~the foot of~~ bluffs and land above overflow.

The office work of this survey is now well advanced. Detailed charts of the Mississippi River, scale 1:20,000, from the Head of the Passes to Davenport, Iowa, and the inch to 1 mile sheets from the mouth of the Mississippi River to near Keithsburg, Iowa, have now all been published. The Upper Alluvial Valley map has been published in two sheets, from Cairo, Ill., to above Burlington, Iowa. The other two sheets of this map are not yet completed. A district map of the lower Mississippi, in convenient form for reference and corrected according to latest information, has just been published.

Gauges and observations.—The permanent gauges of the Commission (14 on the Mississippi, 1 on the St. Francis, and one on the White River) have been maintained throughout the year. The self-registering gauges at Biloxi and Fort Jackson have also been maintained.

The maximum high-water self-recording gauges (182 in number) that have been established at intervals of 5 miles between Cairo and Fort Jackson have been of very great value in recording the heights of the water in the various localities throughout the lower river during the recent flood. The flood plane can now be better established than has heretofore been possible.

During the year discharge and other observations taken with the view of obtaining physical data regarding the river have been kept up. Those taken during the recent flood will be particularly valuable in connection with future improvement of the river and works for the prevention of overflow.

High-water discharge measurements were made at Columbus, Ky.; Helena, Ark.; Arkansas City, Ark.; Warrenton, Miss.; Red River Landing, La., and Carrollton, La. The discharge of the Atchafalaya River at flood stage was also measured.

The question of the change in the conformation and dimensions of the river bed, resulting from levees and other work that has been done, is still undergoing investigation. These have not yet progressed far enough to enable the Commission to arrive at definite conclusions upon this subject.

Dredges and dredging.—The dredging operations have been in charge of the secretary of the Commission during the year. On June 30, 1896, the *Beta* was transferred to his custody by the officer in charge of the First and Second districts, the *Alpha* being already in his charge.

Contracts have been entered into during the year by the secretary of the Commission for the construction of four additional steel-hulled hydraulic dredges, as follows:

1. With John S. George and Howard P. Eells, receivers Bucyrus Steam Shovel and Dredge Company, for the construction of the *Gamma*, at a cost of $85,530.60. This dredge is to have a capacity to deliver 800 cubic yards of material per hour through 1,000 feet of floating pipe. It is now undergoing test and is practically completed.

2. With the New York Dredging Company for the construction of the *Delta*, at a cost of $124,940. This dredge is also to have a capacity to deliver 800 cubic yards of material per hour through 1,000 feet of floating pipe. It is now undergoing test and is practically completed.

These dredges are to be paid for from funds appropriated by the sundry civil act of March 2, 1895, and the river and harbor act of June 3, 1896.

3. With the Springfield Boiler and Manufacturing Company for the

construction of the *Epsilon* and *Zeta*, at a cost, for the former, of $102,000, and for the latter, $106,900.

They are each to have a capacity to deliver 1,000 cubic yards of material per hour through 1,000 feet of floating pipe. They are being built in accordance with plans and specifications prepared by the committee on dredges, and are to be paid for from funds to be appropriated by the deficiency bill now pending in Congress. By the terms of the contract they are to be finished and ready for delivery on or before October 6, 1897. Their construction is now in progress and it is hoped that they will be completed at the time required.

The *Gamma* and *Epsilon* are to be provided with jet agitators, and the *Delta* and *Zeta* with mechanical agitators. The draft of no one of these dredges is to exceed 4½ feet.

When all the work now under contract is completed, the Commission will have a fleet of six dredges with which to improve low-water navigation, whose combined capacity is estimated at about 6,000 cubic yards of material per hour delivered through 1,000 feet of pipe. This capacity is equal to dredging a channel 300 feet wide, 6 feet deep, and over one-half mile long each day.

Repairs.—During the year current repairs have been made to the *Alpha*, at a cost of about $1,450. The main pump and engines of this dredge were not thoroughly overhauled before the beginning of the last working season, as their subsequent performances showed. All during the time that this dredge was in operation it labored under the disadvantage of not being permitted to have its pump run to anything like its proper rating for fear that it would be permanently disabled.

The pump and engine were originally designed for a discharge of 600 cubic yards per hour through 500 feet of pipe. Without any change in design or special preparation, the pump was made to discharge through 1,000 feet. The peripheral velocity that could be given to the disk was necessarily diminished under this condition, and the quantity of material delivered very much reduced. The pump became very much worn by the end of the season, and is now being replaced by a new one. The engine is also being thoroughly overhauled and repaired. When these repairs are finished, this dredge will be in much better condition for the work required of it than it has heretofore been.

The contractor not having complied fully with the requirements of his contract for the construction of the dredge *Beta*, it was only provisionally accepted by the United States after the tests referred to in the last annual report of the Commission. Alterations and renewals were required in certain of the parts which had exhibited a weakness, or inapplicability to the purposes for which they were intended. The most important point on which the terms of the contract were not complied with, and which materially diminishes the efficiency of the dredge, was in the matter of draft. It was provided that when the dredge was fully equipped and ready for work this should not exceed 4½ feet. It was found in actual practice that this draft was as much as 6½ and 7 feet. The dredge was conditionally accepted with the understanding that all these defects and failures to comply with the specifications to the contract should be remedied before final payment would be made to the contractor.

During the year the contractor made a number of the smaller repairs and additions that were required, at his own expense. In addition to these there were current repairs made to the dredge at the expense of the United States, amounting to $3,853.86. At the end of the working season the contractor was requested to make the alterations and additions necessary to diminish the draft to 4½ feet and otherwise complete his contract. This he has failed to do, but a final settlement has been made with him on the basis of the forfeiture of the amount to his credit on account of this dredge in lieu of the unfinished work. The dredge by this arrangement comes unconditionally into the possession of the Government. This conclusion has but recently been arrived at. There is now not sufficient time before the commencement of the next low-water season in which to make these alterations. It is proposed to run the dredge as it is during this season and then make these changes, and at the same time such others as the experience gained may indicate to be necessary to increase its efficiency and diminish its operating expenses.

Dredging operations.—The two dredges, *Alpha* and *Beta*, were in commission from August 28 to November 30, 1896. The balance of the year they were laid up in ordinary and undergoing repairs. Until the commencement of their season's work they were at Memphis, Tenn. Since its close they have been at East Cairo, Ky.

Dredging was done by the *Alpha* at Cherokee Crossing, 89 miles below Cairo; Upper Point Pleasant, 79 miles, and at Compromise Bar, 77 miles; and by the *Beta* at Island No. 40, 211 miles below Cairo; Island No. 34, 179 miles; Osceola, 164 miles; Hathaways Lower Crossing, 102 miles; Cherokee Crossing, 89 miles, and Lower Point Pleasant, 79 miles below Cairo.

The results of the dredging were generally satisfactory to those interested in navigation. An increase of depths from 1 to 4 feet at low stages was obtained at each of these places. The number of dredges being limited and far below what the necessities of the river require, there were naturally some localities where bad navigation prevailed that could not receive attention.

The methods and appliances for handling the dredges and managing their long lines of discharge pipes are yet in their first stages of development, and can be very much improved upon as further experience is gained.

The location of the proper lines upon which to dredge so as to be working constantly with the forces of the river and obtain the best and most lasting results with the least amount of dredge work is a matter of great importance. This depends upon good judgment matured by experience.

All attempts to ascertain the amount of material passing through the pumps by studying the conditions of a locality before and after dredging as shown by surveys must necessarily be futile, on account of the unascertainable quantity involved that is moved by the current of the river. The survey of a bar before dredging is of great importance as indicating the direction of the currents and the movement of the sand—useful information in connection with the location of the line on which dredging is to be done. After the dredging is done, all that is known is that beneficial results have been obtained or they have not. The experience gained during last season on various points bearing upon this dredge work will be of great benefit in the management of the enlarged fleet that will be in operation in the future.

The details of the operations carried on under the directions of the secretary of the Commission are set forth with much minuteness in his report and that of Mr. J. A. Ockerson, the principal assistant in his office, which are herewith transmitted as appendices 7 and 7 E.

CONSTRUCTION.

The construction work, in addition to levee work, carried on during the year under the direction of the Commission, has been confined to such minor bank work as has been necessary for the prevention of cutoffs and the protection of harbors and levee lines of exceptional importance, in accordance with the policy in this respect outlined in last annual report. In some cases the work has been carried on with funds especially appropriated by act of Congress, in others with allotments by the Commission from the general fund appropriated for the improvement of the river.

The Commission is still investigating the question of the protection of caving banks in the hope that some method may be devised for accomplishing this purpose that will be within practical limits of expense. A system of bank heads placed at intervals along caving banks, by means of which they will be held permanently at these points, has been suggested by Lieutenant-Colonel Stickney, Corps of Engineers, U. S. A., in a paper prepared for the Commission. This system appears to have sufficient merit to warrant the expense of trial. Colonel Stickney's paper is forwarded herewith as Appendix 1 to this report.

FIRST DISTRICT (CAIRO, ILL., TO FOOT OF ISLAND NO. 40, 220 MILES).

District officer, Capt. Graham D. Fitch, Corps of Engineers, U. S. A., until May 18, 1897, since which date First Lieut. Mason M. Patrick, Corps of Engineers, U. S. A., has been in charge. The channel and harbor works comprised in the district are Columbus Harbor, Kentucky; Hickman Harbor, Kentucky; New Madrid Harbor, Missouri, and Plum Point Reach.

Columbus Harbor, Kentucky (21 miles below Cairo).—The work here was done in 1889 and 1890, under special appropriations. The object was to prevent further caving of the bank at and below town. It was accomplished by a series of five submerged spurs. The work has accomplished the object for which it was designed, and is still in fair condition. Some caving has occurred in recent years between the dikes where the bank was unprotected. There is no apparent necessity for any additional work.

Hickman Harbor, Kentucky (36 miles below Cairo).—This work was also done under special appropriations. The upper end of the harbor rests upon a bluff. Below this and along the city front serious caving was in progress prior to the construction in 1889 of 930 feet of revetment. In 1892 an extension downstream was made, and the upper bank protection received additional riprap. In 1894 slight repairs were made and an extension of 630 feet built, by which the landing was much improved. There does not appear to be any present necessity for additional work.

New Madrid Harbor, Missouri (71 miles below Cairo).—The work done here is under special appropriation, and has for its object the protection of the town from encroachment by the river. The project contemplates revetting the caving bank in front of the town. In 1893 and 1894 1,600 feet of revetment were constructed here. Caving continued rapidly below the lower end of this. During the last year a farther extension of 500 feet was made with the funds appropriated by the river and harbor act of June 3, 1896. The work must be extended still farther downstream before the town will be fully protected.

Plum Point Reach (147 to 186 miles below Cairo).—Work within this reach is done under the appropriations for the general improvement of the Mississippi River, and in accordance with the general project adopted for that improvement. It consists, therefore, of revetments, closing chutes, and channel work, in the following localities:

A. *Daniels Point revetment.*—This work was originally done in the early stages of work of this character, by the methods then adopted, which have since proven to be inadequate to the requirements of the situation. The original work in 1891 had a length of 5,300 feet. Repairs were made in 1892 and 1893, but in 1895 only 900 feet of it remained in good condition. The damage was mainly to the upper bank revetment, the subaqueous parts remaining serviceable for repairs. In 1895 the work was generally repaired and extended upstream 5,000 feet by improved methods, which have given more satisfactory results.

The work of the last year consisted in repairs to the revetment at the junction between the work of 1889 and 1895. This was at a projecting point exposed to an extremely rapid current. The cave was 400 feet long and extended into the bank 120 feet. The repairs were made, but owing to the strong current and rising river at the time not in as satisfactory manner as was desired.

There is still some caving near the head of this work, which will require that the revetment be extended in that direction.

B. *Ashport Bend revetment.*—This work was commenced in 1891 and continued through 1894, by which time 16,300 feet had been built. It has entirely arrested the caving in the bend and is now in good condition. There is at present no reason for its extension.

C. *Fletchers Bend revetment.*—The protection of this bend was commenced in 1884 and added to from year to year. In 1891 it had a length of 16,500 feet. It was not continuous, as toward the lower end the experiment of detached revetment was tried. The blocks were 1,100 feet long, with intervals of 300, 400, and 500 feet. The result was that caving in the intervals was not entirely stopped, and the ends of the sections were flanked. The further experiment was tried of holding the ends of these detached sections with loose masses of stone, which are intended to follow and check any scour from eddies that may occur.

The work done in this bend during the past year was the extension of the revetment southward, and the construction of a spur dike of brush and stone in the pocket opposite Elmot Landing, Ark., to prevent further enlargement. This pocket had increased in length to 650 feet, and the recession of the bank line in the middle was about 250 feet. These conditions produced a strong eddy, which endangered the revetment both above and below.

D. *Gold Dust Chute Dam.*—The excessive width of the river where it is divided by Elmot Bar and Island No. 30 made channel contraction works a necessity in this locality. The earlier works used for this purpose did not possess the requisite stability. In 1893 a stone dam resting upon a broad foot mat was constructed in the chute. With some repairs this has answered the purpose very well and given good results. The dam is now in fairly good condition.

E. *Osceola Bar revetment.*—The protective work along the front of this bar is in fairly good condition. Caving is going on above the head of this revetment which may require its extension in that direction to prevent its being flanked.

F. *Bullerton Towhead revetment.*—The revetment placed on this towhead during the early attempts of the Commission to regulate the channel in this locality was too narrow and too light in character to withstand the excessive current that eventually impinged against it. It was replaced in 1893 and 1894 by a wider and more substantial structure. This has remained in good condition and is effectually holding the bank.

It will be remembered that Plum Point was one of the reaches of bad navigation in which the rectification of the channel was undertaken by the Commission immediately upon its organization. Much experimental work was done here before proper methods for accomplishing the objects to be attained were thoroughly developed. In addition to the works at the six points here mentioned, a great deal of channel contraction work was done. This was of a temporary character and done with perishable material. It has long since disappeared.

The record of the operations carried on here and the results produced are demonstrations of the correctness of the theory on which the work of improvement was based. The works constructed produced an immediate and marked improvement in the low-water channel depths, which, to a certain extent, have been maintained ever since. Recent changes above the reach, however, are threatening changes within it, from which serious impairment of channel is liable to occur.

SECOND DISTRICT (FOOT OF ISLAND NO. 40 TO THE MOUTH OF WHITE RIVER, 180 MILES).

District officer, Capt. Graham D. Fitch, Corps of Engineers, U. S. A., until May 18, 1897, since which date First Lieut. Mason M. Patrick, Corps of Engineers, U. S. A., has been in charge. The works of channel and harbor improvement in this district are the revetment of Hopefield Bend, Memphis Harbor, the deepening of Wolf River, the removal of Nonconnah Rock, and the revetment of the bank in Helena Harbor, Arkansas.

Hopefield Bend (Arkansas) revetment (227 miles below Cairo).—The object of this work is to hold Hopefield Point so as to throw the channel crossing from the right to the left bank of the river as high up as possible, with the view of keeping navigable water along the whole of the city front of Memphis. The work was one of the first commenced by the Commission. It is now about 16,000 feet long, and extends from Mound City Landing to the end of the point. It was begun in 1882 and completed in 1888. Extensive repairs were made to the lower 10,000 feet from 1890 to 1893. Only minor repairs have since been made. The work has been done under both general and special appropriations.

During the recent flood of 1897 some damage was done near the lower end, the extent of which has not yet been determined. The maintenance of this point is recognized as an essential factor in the preservation of the harbor of Memphis.

Memphis Harbor (230 miles below Cairo).—This work is being done under special appropriations. The landing at Memphis was protected some years ago by its citizens, and subsequently they built a series of spurs below. The bank for a distance of 10,166 feet was protected by the United States. At the date of the last Annual Report there remained an unprotected portion of the bank about 2,400 feet long between the lower end of the Government revetment and the revetment placed by the bridge company to protect the east end of their bridge. During the fall of 1896 about one-half of this gap was closed by the construction of 1,212 feet of revetment. The remaining gap of 1,200 feet should be closed as soon as funds can be provided. There has been some recent caving of the high bluff along this stretch.

Wolf River.—This stream, at the upper limit of the city of Memphis, has a local importance because of the railroad transfer landings and large lumber and other interests in the vicinity. Its improvement has been the object of special appropriations in connection with Memphis Harbor. It consists in dredging through the bar at the mouth and clearing away deposits of sawmill waste and other refuse material that has been allowed to accumulate. Since this was done the channel through the bar has become fairly fixed and improved in depth.

Nonconnah Rock (*236 miles below Cairo*).—This improvement is being done by an allotment from the appropriations for the general improvement of the river.

These rocks are a detached outcrop, bare at low water, of ferruginous sandstone and cemented gravel from the bluffs on the Tennessee shore. The continual recession of the east bank has left them about 700 feet from the shore and in the direct line of the navigable channel. They are, consequently, a serious menace to passing river craft and commerce. During last year the greater portion of these obstructions was removed. There are still left some points having only a depth of 6 feet over them at low water. It is proposed to remove these down to a depth of 8 feet at that stage.

Helena Harbor (*306 miles below Cairo*).—This improvement, under special appropriations, was commenced in 1889 by the construction of 600 feet of revetment along the immediate front of the city and of five spur dikes below the business portion of the town. Since that time both the caving and the town have extended downstream.

The work of last year done with the funds appropriated by the river and harbor act of June 3, 1896, consisted in repairs to and protection of the work already done and the farther extension of the revetment downstream. The extent of bank now protected at this place amounts to 4,110 feet. A farther extension downstream is deemed to be necessary.

LEVEES, SURVEYS, AND PLANT.

The operations connected with levees in the First and Second districts, under the charge of Captain Fitch, together with those of the Third and Fourth districts, under charge, respectively, of First Lieut. H. C. Newcomer and Capt. George McC. Derby, are the subject of discussion under one continuous head in a subsequent part of this report.

The usual surveys and observations in the First and Second districts, as likewise such additional ones as were called for by the Commission and the necessities of the work in hand, were made during the year. The usual care and such repairs as were necessary were given to the plant. A part of this plant pertaining to dredge operations was transferred to the Secretary of the Commission. A new towboat for these districts is now in process of construction.

For further details of the transactions in the First and Second districts reference is invited to the report of Capt. G. D. Fitch, Corps of Engineers, U. S. A., and to the reports of his assistant engineers, A. J. Nolty, William Gerig, and Charles Levasseur, which appear as Appendixes 8, 8 A, 8 B, and 8 C, respectively.

THIRD DISTRICT (MOUTH OF WHITE RIVER, ARKANSAS, TO WARRENTON, MISS., 220 MILES).

Capt. C. McD. Townsend, Corps of Engineers, U. S. A., continued in charge of this district until July 27, 1896, at which time he was relieved, temporarily, by Capt. Graham D. Fitch, Corps of Engineers,

U. S. A., who remained in charge until August 27, 1896, when he was relieved by First Lieut. H. C. Newcomer, Corps of Engineers, U. S. A.

Channel and harbor work has been done in this district at Lake Bolivar Front, Ashbrook Neck, Greenville Harbor, Lake Providence Reach, and Delta Point.

The operations under these heads during the past year have been confined to repairs to broken revetments at Greenville and Louisiana Bend and the care of plant.

Lake Bolivar Front (*417 miles below Cairo*).—The work of revetting the bend of the river at this point was commenced under a special appropriation made in 1888. Its object was to preserve an important levee between the lake and the river and obviate the necessity for building a new and expensive levee around the lake. Since commencing the work 4,885 feet of bank has been revetted and some repairs have been made. No work has been done since 1894. The surveys of recent years show a fill over the revetment, and it is protected by a bar making downstream from the foot of Island No. 76. The revetment is apparently in good condition for about 3,775 feet. The work, together with the changes taking place in the river, is accomplishing the object to be attained, and no farther extension is at this time considered necessary.

Ashbrook Neck (*446 miles below Cairo*).—The work of revetting a caving bank at this place is being done from appropriations for the general improvement of the river. Its object is to prevent a cut-off which would result in a general change in the regimen of the river for several miles both above and below, a more rapid erosion of the banks, and the destruction of important and expensive lines of levees.

The work was commenced in 1890. Since that time 11,205 feet of bank has been revetted. Repairs have been made from time to time. No work was done during the last year. There is now about 9,990 feet in effective condition. The work has arrested the caving where applied, but it is considered advisable that it be extended farther upstream in order to completely protect the bend. It is probable that it will become necessary in the near future to undertake the protection of Tarpleys Neck, below Ashbrook.

Greenville Harbor (*478 miles below Cairo*).—This work is being done under special appropriations. Its object is to protect the town of Greenville and adjacent levees from rapid encroachments by the river, which threatens their destruction and the inundation of the Yazoo Basin.

Work was commenced here by the citizens in 1887. A series of spur dikes, consisting of cribs resting on foundation mats, was then built. During this and the next two years twelve of these spur dikes and a longitudinal dike were built. Caving continued in the bend above these which resulted in their being flanked, and four of the spur dikes and the longitudinal dike were carried away. In this portion a continuous revetment was commenced in 1891 and continued until 14,134 feet of bank had been protected. In the flood of 1894 the remaining upper spur dike was carried away, leaving seven spur dikes still in position. From time to time since its inception this work has required repairs mainly in the parts first built.

The work during the last year has been confined to repairs to a break made in the revetment by the spring flood of 1896.

On April 5, during the recent flood, a break occurred in this revetment, and on May 18 a second break was reported. At the date of last advices the flood had not subsided sufficiently to permit the extent of the damage to be accurately determined, but the breaks are apparently about 300 feet long at each place. It will probably be necessary to make repairs here during the coming season.

Without deducting these breaks the length of revetment in effective condition is about 12,165 feet. There is also about 2,900 feet of bank protected by the dikes.

These three improvements—Lake Bolivar Front, Ashbrook Neck, and Greenville Harbor—are illustrative of uses for which the best type of bank protection will always be required on the Mississippi River in the preservation of levee locations which can not be abandoned except at immense cost and loss, the prevention of cut-offs, and the maintenance of harbor lines and city fronts.

Lake Providence Reach (*517 to 552 miles below Cairo*).—This is the second of the two reaches selected by the Commission for systematic treatment. The depth in its navigable channel at the crossings during low water was at times reported to be only 4½ and 5 feet. The width of the river in this region was excessive. The original project provided for giving the low-water channel an approximately uniform width of 3,000 feet by constructing contraction works, closing chutes, and preventing erosion in concave banks.

Instead of covering the entire reach of 35 miles, as was originally intended, the work was confined to a reach of 20 miles, between 522 and 542 miles below Cairo.

Operations were begun in 1882, and actively prosecuted during the three following years. Some repairs were made to these earlier works up to 1889. These works, consisting of bank protection and contraction works, are now practically gone; the former, because a method of construction of sufficient width and strength of mattress had not been used, and the latter, because their continued usefulness was dependent upon the ability of the former to protect the adjacent and opposite banks. When the revetment failed, this involved the destruction of the contraction works.

A marked improvement in the low water channel in this locality was effected by these works. Notwithstanding that they are now practically obliterated, the channel has not yet reverted to anything like its former conditions of difficult and almost prohibitory low-water navigation.

Work is now in progress in only two localities in this reach, viz, Louisiana Bend, and the right bank immediately above the town of Lake Providence. At both of these the work is being done under the appropriations for the general improvement of the river.

In 1889 active work was resumed in Louisiana Bend with the view of holding this caving bank and giving permanence to the channel throughout the reach below. Since this time 17,083 feet of bank revetment has been made. The type used was much stronger than that formerly employed.

It has been necessary each year to make more or less repairs to this revetment, as portions have been carried away.

The work carried on here during the last year was confined to these repairs. There is now about 15,820 feet of this in apparently effective condition.

Revetment above the town of Lake Providence (*540 R.*).—This was built with a view to stopping the erosion of the river bank in this locality where important levee interests and the town of Lake Providence are threatened. Should the caving of the bank not be arrested, many miles of new and expensive levee would become necessary around the back of Lake Providence, in order to save valuable farming property.

The work was commenced in 1894. Since this time 10,140 feet of bank has been revetted. No repairs were made to this during last season. It is practically all in good condition. In its construction every precaution and every improvement which previous experience had indicated to be necessary in work of this character were here applied. It is not apparent that any further extension of this work will be necessary in the near future.

Delta Point revetment.—This work is so closely connected with the improvement of Vicksburg Harbor that it may justly be considered as a part of the project having that object in view. So far as relates to the general improvement of the navigation of the river or to the protection of any extended levee interests, it is a matter of doubt whether the cost of the maintenance of Delta Point in its present position would be justified by the benefits gained; but when considered in connection with the reestablishment of river communication at all stages with the city of Vicksburg, it becomes of the very greatest importance. If this point be once permitted to recede, or the bend above it be not firmly held, there will be small hope of maintaining successful river traffic with that city, without moving its landing several miles lower down the river.

The first operations undertaken for the improvement of this harbor consisted in revetting the caving bank at this point. From 1878 to 1881, before the work was placed under the supervision of the Commission, there were built here 5,400 feet of revetment, one spur dike, and two screen dikes. Since 1882, when the work came under the supervision of the Commission, there has been built 6,448 feet of revetment. Practically all the work prior to 1882 has been destroyed or covered by later work. About 5,050 feet of the revetment is still in position. The work is now in need of general repairs, and eventually will have to be extended upstream to a considerable distance.

The improvement of Vicksburg Harbor is now in charge of the Engineer Department.

The levees in this district, as likewise those in the several other districts, are treated of in a subsequent part of this report under the general head of levees.

Full details concerning the operations of this district are found in reports of First Lieut. H. C. Newcomer, Corps of Engineers, U. S. A., and of the assistant engineers, Arthur Hider, H. St. L. Coppee, E. C. Trollinger, and J. D. Van Meter, to which reference is made; Appendixes 9, 9 A, 9 B, 9 C, and 9 D.

FOURTH DISTRICT (WARRENTON, MISS., TO HEAD OF THE PASSES, LOUISIANA, 453 MILES).

District officer Capt. Geo. McC. Derby, Corps of Engineers, U. S. A., with First Lieut. Chas. S. Riché, Corps of Engineers, U. S. A., assistant until September 15, 1896; and additional Second Lieut. Geo. M. Hoffman, Corps of Engineers, U. S. A., assistant from October 1, 1896, to June 10, 1897.

The works of channel and harbor improvement in this district include the harbor of Natchez, Miss., and Vidalia, La.; improvements at the junction of the Mississippi, Red, and Atchafalaya rivers, harbor of New Orleans, La., and dredging channel across a bar in the Mississippi River at Fords.

HARBOR OF NATCHEZ, MISS., AND VIDALIA, LA. (700 MILES BELOW CAIRO).

This work is being done under a special appropriation. The harbor common to the two cities is immediately below Cowpen Point, through which there is imminent danger that a cut-off may be made. The effect of this would be the rapid and extensive caving of the Vidalia front and the formation of bars along the Natchez side of the river, with the loss of its landing. Both of these places have a large river and rail commerce, and their manufacturing interests are important.

The project for the work contemplates the revetting of Giles Bend on the upper side of Cowpen Neck. With the view to temporarily arresting the threatened cut-off, a spur levee has been built from the bluff out along the axis of the point, to check the water flowing across at flood stages, which, it was feared, might start washouts and develop a cut off.

During the past year a contract was made for enlarging the levee on Cowpen Neck to a grade of 5 feet above high water. This work was about half completed when interrupted by the rapidly rising river. About 5,000 tons of rock were purchased and received for the contemplated revetment of Giles Bend. A portion of the plant necessary for carrying on this work has also been purchased.

Contracts are now being made preparatory to beginning the revetment of Giles Bend early in July next. With the funds now available it is estimated that about 6,000 feet of the bank may be protected. The original project contemplated that 16,000 feet of bank should be revetted. Funds must therefore be provided for revetting at least 10,000 feet more of the bank.

Caving of the bank is now going on at a rapid rate throughout the bend. If allowed to continue, the cut-off will surely take place and do not only all the damage originally anticipated, but destroy the new levee on Cowpen Neck, and all the money heretofore expended upon this work will be wasted. It would seem imperative that funds should be liberally provided for this work at an early day.

JUNCTION OF THE MISSISSIPPI, RED, AND ATCHAFALAYA RIVERS, LOUISIANA (764 MILES BELOW CAIRO).

Detailed descriptions of the difficulties encountered at this locality have been given in previous annual reports of the Commission, particularly those of 1892 and 1895. In general terms these difficulties consist in the silting up of Old River, the only navigable route forming a connection between the three rivers, so as to impede and at times entirely interrupt low-water navigation. The project that has been entered upon for ameliorating this condition of affairs is to check the enlargement of the Atchafalaya and limit its outlet capacity by a system of low-relief dams or sills; to separate the Red from the Atchafalaya during low water and up to a 10-foot stage by means of a low dam at the west of Turnbull Island, which would deflect the Red River around the upper side of the island, and to form a new outlet for the Red River into the Mississippi by cutting through Carrs Point, and obstructing the lower end of upper Old River, lower Old River to be kept open by dredging, if necessary, so as to afford a navigable channel into the Atchafalaya.

Two sill dams near the head of the Atchafalaya, with shore protection, connecting levees, and wing levees, have been completed. The sills, or foot mattresses, and shore protection work of the Red River dam have been finished, and the dam constructed to a height of 3 feet above the zero of the Barbre gauge, excepting a length of 450 feet left for the accommodation of low-water navigation while the project is in execution. A hydraulic dredge has been built, and for three seasons navigation through lower Old River has been kept open continuously by dredging. During last season a depth of 5½ feet at extreme low water was maintained, which is a greater depth than is found at that stage in the reaches of the Red River above. The conditions which now prevail seem to be satisfactory to those interested in the navigation of the Red and Atchafalaya rivers. Until further necessity is shown for proceeding with the adopted project for the permanent improvement, it is proposed to confine operations in this locality to dredging in the lower Old River and preventing a further enlargement of the head of the Atchafalaya.

NEW ORLEANS HARBOR (966 MILES BELOW CAIRO).

The general object to be attained by the work in progress in this locality is to prevent the caving of the river banks within the limits of the harbor. The city of New Orleans and all the valuable property in its vicinity are protected from overflow at high water only by the levees built along the edge of the banks of the Mississippi River. The river is constantly at work eroding and undermining these banks. At any moment the levees may be bodily precipitated into the stream and a disastrous inundation result. Lives may be lost, valuable property destroyed, commerce disarranged, and innumerable other interests inconvenienced.

Under the approved project the work to accomplish this object consists in the construction of submerged inclined spur dikes, with mattress revetment between them when found necessary. On account of the limited and irregular appropriations made for this work, they must be expended in protecting localities where necessity for work is most urgent. Regular and systematic progress is not possible under these conditions.

At the date of the Commission's last report work had been done in Carrollton Bend, Greenville Bend, Gouldsboro Bend, and in the Third District Reach. The work accomplished during the last year consisted in completing four spurs in the Third District Reach, the foundation mats for which had been laid two years previous, and in constructing four new spurs to reduce to one-half the intervals between spurs previously built. The work is successfully accomplishing the object for which it was constructed.

To carry on a work of this character requires a plant of considerable magnitude, and this, to be economical, should be constantly employed. Deterioration in this climate will take place when the plant is idle even more rapidly than when employed. Short seasons of work and long seasons of idleness require large expenditures for repairs and preservation, often out of all proportion to the amount of work done. Every consideration would seem to require that liberal appropriations should be made for this work, and that it should be pushed to an early completion.

Dredging at Fords Crossing.—During low-water season trouble is sometimes experienced at Fords Crossing, 6 miles below Natchez. To increase the depth of water here at that season, the officer in charge of this district was authorized to use the dredge which had been provided for improving the channel at the mouth of the Red River when it could be spared from this work. During last October this dredge worked here about three weeks, making a channel 1,900 feet long and 100 wide. A depth of 12 feet below extreme low water was obtained. A survey made before commencing work showed the best water on the bar to be but 6½ feet.

SURVEYS AND OBSERVATIONS.

Very little work of this character has been done by the district officer during the past year. Comparative sections of the Mississippi River were sounded at Red River Landing, Carrollton, and Pointe-a-la-Hache, and a survey of the channel at Fords Crossing was made. Soundings have also been taken over the sill dams in the Atchafalaya River to determine their condition.

The plant has been cared for and repairs made as far as practicable.

The levees of this district also form part of a general description of the system under the special heading treated of later on.

Full details of the operations of this district will be found in the Appendixes 10, 10 D, 10 E, 10 F, 10 G, 10 H, 10 I, and 10 J, respectively, which contain the reports of Capt. Geo. McC. Derby, Corps of Engineers, U. S. A., and Assistant Engineers A. F. Wooley, jr., H. S. Douglas, W. J. Hardee, and H. B. Watson, surveyor.

LEVEES.

LEVEES OF THE FIRST DISTRICT.

Capt. G. D. Fitch, Corps of Engineers, U. S. A., in charge to May 18; since that date First Lieut. Mason M. Patrick, Corps of Engineers, U. S. A.

Lower St. Francis Levee district (from 80 to 298 miles below Cairo).—The levees of this district extend from about 1 mile above Point Pleasant to about 4 miles below Pecan Point. The total contemplated levee line amounts to about 224 miles, of which 115 has been constructed. This work was done partly by the United States and partly by the local levee boards. The State of Missouri has built 26 per cent, the State of Arkansas 40, and the United States 34 per cent of the length of the line.

The area that will be protected by the levees when completed is about 3,490 square miles.

The work accomplished during the last year consisted in enlarging the levees to a grade of 4 feet above high water of 1882 from Bear Bayou, Arkansas, southward for a distance of about 6 miles. There was put in place by the United States 154,241 cubic yards and by the local levee boards 33,061 cubic yards, making a total of 187,302 cubic yards. The total yardage now in place is 5,260,570 cubic yards. Of this the United States has paid for nearly 53 per cent. This amount does not include 170,000 yards, or about 3 per cent of the whole, estimated to have been abandoned or lost on account of crevasses due to the flood of 1897.

The grade established for the levees of this district is, beginning at Point Pleasant, 2 feet above high water of 1882, increased successively in certain stretches throughout the distance to the mouth of St. Francis River to 3, 4, and 5 feet. The estimated yardage required to complete the levee throughout the whole distance to standard section and grade and close the gaps made by crevasses is 6,087,145 cubic yards.

The flood of 1897 was higher on all the gauges along this front than any of previous record. It would therefore seem probable that in order to protect against floods of this magnitude a still higher and stronger levee than that contemplated will be necessary.

LEVEES OF THE SECOND DISTRICT.

Capt. G. D. Fitch, Corps of Engineers, U. S. A., in charge until May 18; since that date First Lieut. Mason M. Patrick, Corps of Engineers, U. S. A.

White River Levee district (306 to 385 miles below Cairo).—The levees of this district are intended to close the river front from the mouth of the St. Francis to the mouth of the White River. The length of the levee line is 64.4 miles. The territory to be protected is a narrow strip varying from 6 to 30 miles in width, lying on the right bank of the Mississippi River, having an area of about 910 square miles.

With the exception of the first 40,000 feet below Helena, this line has been mainly built by the United States since 1885, using the available fragments of an earlier line constructed by local organizations and riparian owners.

At the date of the last annual report this levee was all up, but a considerable portion was below established grade. The work of the last year was confined to enlarging and completing the line so far as the funds allotted would suffice. There were constructed by the United States 191,442 cubic yards and by local boards 105,000 cubic yards, making a total of 296,442 cubic yards.

There is now in place in this district 5,889,044 cubic yards. This does not include 344,000 cubic yards of abandoned levee due to crevasses caused by flood of 1897. Nearly 84 per cent of the whole amount has been paid for by the United States. The abandoned levee amounts to about 5½ per cent of the whole.

The present grades in this district are as follows:

From Helena, Ark., to 19 miles south, from 1½ to 3 feet above high water of 1890; thence to 345½ R., a length of about 21 miles, 4 feet, the grade line being a practically uniform slope, with each terminal 4 feet above high water of 1890; from this point south to the end of the system, a distance of almost 24½ miles, the grade is 3 feet above high water of 1890, except for a distance of 4,000 feet near the lower end, where it is 2 feet.

The flood of 1897 overtopped these levees nearly all along the line, and was an average of 4 feet above the high water of 1890. It is estimated that to close the gaps and reestablish these grades 975,500 cubic yards of earthwork will be necessary.

To protect against floods of this magnitude higher and stronger levees will be necessary along this front.

Upper Yazoo Levee district (244 to 365 miles, left bank, below Cairo).—This district extends from near the boundary line between Tennessee and Mississippi to the Coahoma-Bolivar county line, Mississippi, a distance of 121 miles by the river. It contains 124 miles of levees which, together with the levees in the lower Yazoo district, protect the Yazoo Basin, containing about 7,151 square miles, from overflow.

Since 1882, by the flood of which year it was badly wrecked, it has been improved by the joint efforts of the State and the United States.

During the last year the work done by the United States was confined mainly to enlarging existing levees. There were constructed by the United States 378,792 cubic yards and by local boards 830,233 cubic yards, making a total of 1,209,025 cubic yards. There is now in place 12,793,495 cubic yards, nearly 34 per cent of which was constructed at the expense of the United States. This does not include 144,730 cubic yards abandoned and lost by crevasses.

The grades along the upper portion of this levee system for a length of 42½ miles are 5 feet above the high water of 1882; thence to mile section 49, inclusive, they are 2 to 3½ feet above high water of 1890; sections 50 to 53, inclusive, they are 4½ to 5 feet; sections 54 to 56, inclusive, are 3½ to 4 feet; section 57 is 3 to 4 feet; sections 58 to 69, inclusive, 4 feet; sections 70 to 82, inclusive, they are generally 4 feet, all above high water of 1890.

The high water of 1882 was the highest known along the upper portion of the Yazoo front, while those of 1892 and 1893 were the highest along the lower portion until the flood of 1897.

It is estimated that to close the gaps and fully establish the levees to these grades will require 2,823,000 cubic yards.

It is conceded that the pressure along this entire front is much less than it would have been had not the levees of the lower White River district along the right bank of the Mississippi River given way in so many places as they did during the flood of 1897. When that system is restored and strengthened this one will likewise require to be raised and enlarged if floods of this magnitude are to be provided against.

LEVEES OF THE THIRD DISTRICT.

First Lieut. H. C. Newcomer, Corps of Engineers, U. S. A., in charge.

Lower Yazoo Levee district (*from 365 to 592 miles below Cairo, left bank*).—This district extends from the Coahoma-Bolivar county line, in Mississippi, to the mouth of the Yazoo River. The levee line is continuous, disregarding the crevasses made by the recent floods, from its upper end to Eagle Lake. Its length is 186 miles, covering about 215 miles of the river. The line was built by a State organization before the war and was maintained in tolerable order until 1882, when it shared the general wreck of that year. Since that it has been restored, maintained, and improved by the joint efforts of the State and United States authorities.

The work done during the last year has been confined to renewing and strengthening the line. The yardage put in place by the United States was 256,153 cubic yards, and by the local boards 1,418,239 cubic yards, making a total of 1,674,392 cubic yards. The total yardage now in place is about 22,174,392. The cost of about 6,962,600 cubic yards, or 31 per cent, has been paid by the United States.

The adopted provisional grades for levee work in this district are 5 feet above previous highest water, north of Greenville, and 4 feet south of that point.

The highest reading on the gauge at Vicksburg during the flood of 1897 was 52.5, which is 3.5 feet above the flood of 1890.

Upper Tensas Levee district (*402 to 604 miles below Cairo, right bank*).—This district extends from the Arkansas River to a point in Louisiana opposite Warrenton, Miss. Its limits have been changed since last annual report of the Commission by consolidating the Middle Tensas district and the Upper Tensas district into one.

The levee lines of this district are about 173 miles long, extending from Costellos Gin, on Amos Bayou, along that bayou and Cypress Creek to the Mississippi River (13 miles), and thence along the river to the lower end of the district (160 miles). The district is protected from overflow of the Arkansas River by a levee line running along that river from the vicinity of Pinebluff to the foot of Lake Jefferson. From Pinebluff to Redfork this line is of comparatively weak section, built and hitherto maintained by the local authorities. From Redfork to the foot of Lake Jefferson (12½ miles) the line was built in 1894–1896 by the United States. These levees form the head of the system which protects the great Tensas Basin from overflow.

The work during last year consisted of repairing and enlarging the existing levees.

There were put in place by the United States 530,913 cubic yards, and by local boards 124,591 cubic yards, making a total of 655,504 cubic yards.

There has been put into these levees 21,996,612 cubic yards of earth, of which amount the United States has paid for 15,395,220 cubic yards, or 70 per cent.

The adopted grades for levee work in this district are 4 feet along Amos Bayou and Cypress Creek, 4½ feet along Mississippi River in Arkansas, and 5 feet in Louisiana above the highest known high water prior to 1897. Much of the line is below these grades.

The highest stage reached at Arkansas City during the flood of 1897 was 51.9, or 1.7 feet above the high water of 1893.

LEVEES OF THE FOURTH DISTRICT.

Capt. Geo. McC. Derby, Corps of Engineers, U. S. A., in charge; First Lieut. C. S. Riché, Corps of Engineers, U. S. A., assistant until September 15, 1896, and additional Second Lieut. Geo. M. Hoffman, Corps of Engineers, U. S. A., assistant from October 1, 1896, to June 10, 1897.

Lower Tensas Levee district (from 606 to 764 miles below Cairo, right bank).—This is a continuation of the Upper Tensas district down to the mouth of the Red River. The levee is continuous from the upper end opposite Warrenton, Miss., down to a point about 5 miles below Fairview Landing, a distance, by river, of 126 miles, leaving a gap of about 30 miles unprotected.

This levee was originally built by the authorities of the State of Louisiana, and was destroyed by the great flood of 1882. Since that time both the State and the General Government have contributed to its repair and enlargement. Its present length is about 131 miles.

During the last year there were added to the line by the United States 165,034 cubic yards, and by State and local boards 996,127 cubic yards, making a total of 1,161,161 cubic yards.

There has been lost by abandonment and crevasses caused by flood of 1897 38,000 cubic yards. The aggregate yardage remaining is 12,766,527.

The grade now adopted for this levee is 5 feet above the highest water known prior to 1897. The highest reading at Natchez during the flood of 1897 was 49.8, which is 1.2 feet above the high water of 1890 at that point.

Atchafalaya Levee district (764 to 886 miles below Cairo, right bank).—This levee district extends from the mouth of the Red River to the head of Bayou Lafourche. These levees, which are 128 miles in length, were maintained exclusively by the State of Louisiana until the flood of 1882. Since that time they have been enlarged and maintained by the cooperation of the State and General Government.

During the last year 864,684 cubic yards was added to the levees by the United States, and 254,588 cubic yards by the State and local boards. There were 39,000 cubic yards lost by abandonment during the year. The aggregate of the remaining yardage is 13,763,082.

The grade adopted for the levees in this district is 4 feet above the highest known water prior to the flood of 1897. A large portion of the levee is still below this grade.

The highest water of the flood of 1897 read 40.65 feet at Baton Rouge, which is 2.2 feet above the highest previous water of 1892.

Lafourche Levee district (886 to 957 miles below Cairo, right bank).—The levee line of this district is continuous from Bayou Lafourche down to the city of New Orleans. Its past history is similar to that of Atchafalaya. Its length is 75 miles.

During the last year 352,642 cubic yards was added to it by the United States, and 59,126 cubic yards by the State and local boards. The total yardage now in place is 6,583,042.

A grade of 4 feet above highest known water has been adopted for this levee. Much of it is still below that height.

The highest reading at College Point during the flood of 1897 was 27.95 feet, which is 2 feet above the highest previous flood of 1893.

Barataria Levee district (957 to 1,060 miles below Cairo, right bank).—This is a continuation of the Lafourche Levee district, a division made for convenience of administration. The levee system is continuous down to the Jump, with a length of 71.5 miles.

During the last year a yardage of 180,226 was added by the United States, and 37,756 by the State and local boards. There was lost by abandonment 22,000 cubic yards. There is now in place 2,098,008 cubic yards.

The grade established for this levee is 3 feet above the highest water known prior to 1897. The lower half of this levee is still below this grade.

The highest water of the flood of 1897 read 19.05 on the Carrollton gauge, which is 1.6 feet above prior highest water of 1893.

Pontchartrain Levee district (833 to 957 miles below Cairo, left bank).—This district extends from Baton Rouge to New Orleans and has a continuous levee line of 123.5 miles.

During last year a yardage of 476,256 was added by the United States, and 61,938 by the State and local boards. There was lost by abandonment 14,000 cubic yards, leaving now in place 11,137,516 cubic yards.

The established grade for this levee is 4 feet above highest water known prior to 1897. Much of this levee is still below that height.

The flood of 1897 reached 27.95 feet at College Point, which is 2 feet above the highest prior high water of 1893.

Lake Borgne Levee district (965 to 1,060 miles below Cairo, left bank).—The levees in this district are continuous from Jackson Barracks, at the lower limit of the city of New Orleans, to Fort St. Philip, covering about 70 miles of river front.

During the last year there was an addition of 49,450 cubic yards made to it by the United States, and 91,013 cubic yards by State and local boards. There is now in place 2,485,215 cubic yards.

The established grade for the district is 3 feet above highest known water, prior to 1897. The lower half of this levee is still below this grade. The highest point reached on the gauge at Fort Jackson during the flood of 1897 was 7.2 feet, which is 0.3 feet higher than the prior highest water of 1891.

It may be noted here that the cordial cooperation and good understanding heretofore existing between the representatives of the United States and the State and local boards interested in the construction and maintenance of these levees still continues, and the Commission will take this opportunity to express its appreciation of the many courtesies extended to its Government employees by the citizens generally, and especially by the representatives of the State and local boards.

STAGES OF THE RIVER.

During the last year the river did not reach at any time the excessive low-water stage that it did during the preceding year. The stages were what may be termed ordinary low waters. There is, therefore, nothing out of the usual course to report under this head. With regard to the high water, however, the case is different.

Flood of 1897.—This season will long be remembered as one of unprecedented high water in the lower Mississippi River. At all points below New Madrid (70 miles below Cairo) the water reached a higher stage than any other of which we have authentic record. This water is remarkable, not only on account of its height, but also by reason of the duration of the flood.

The high water of this season in the Ohio River reached its maximum of 61.1 feet at Cincinnati February 26. The highest previous record at that place was 71.06, February 14, 1884. The Cumberland at Nashville reached its maximum of 49.25 feet this season, March 20. The highest previous record was 55.3 feet on January 22, 1882. The Tennessee River at Chattanooga reached its maximum on March 15, at 37.9 feet, the highest previous record being 54 on March 1, 1875. As these flood waters passed into the Mississippi they resulted in a maximum height of 51.6 feet at Cairo March 25, 1897. The crest of the first wave had scarcely passed by when it was followed by another which did not reach quite to this height. The highest previous record at Cairo is 52.2 feet, February 27, 1883. The water reached a stage of 49 feet on this gauge March 14, and remained practically at or above that stage until April 17, a period of thirty-four days. No previous flood has ever prevailed at this point for anything like so long a time. The Upper Mississippi was not above medium high stage during this time, and fortunately the tributaries to the Mississippi below Cairo were not above the medium stages when the flood wave passed them.

The crest of the flood wave reached New Madrid, Mo., March 29, with a reading of 40.27 feet, which is about 0.8 foot lower at that point than previous high water in 1884. It remained above 40 feet from March 24 to April 4.

At Cottonwood Point, 123 miles below Cairo, the flood reached its maximum stage at 39.3 feet March 22, which was 1.5 feet above the highest previous water in 1883. Breaks in the levee line in this vicinity prevented the water from going still higher. It remained above 39 feet from March 19 until April 2.

At Helena, Ark., the flood reached its highest point of 51.8 feet April 4, exceeding the highest previous record, 48.1 feet in 1886, by 3.7 feet. On that day, in consequence of breaks in the levees below, the water commenced to fall. The flood remained at or above 48 feet from March 20 until April 15.

At Arkansas City the maximum stage was reached on March 29 and read 51.9 on the gauge. This is 1.6 feet higher than the highest previous record, which occurred in 1883. The levees on the White River front and also at two points on the Mississippi side had broken prior to March 29.

At Greenville the maximum was also reached on March 29, at a height of 46.8 feet on the gauge and 2.5 feet higher than the previous highest record, which occurred in 1893. The break in the levee at Deerfield

(492 L.), which occurred March 28, evidently checked the river here at a point below the maximum that might have been reached.

At Lake Providence the maximum was reached on March 30, at a reading of 44.4 feet on the gauge. This was 2.5 feet above the highest previous record, which was made in 1892.

At Vicksburg the river reached 49.4 feet on April 1. This was the maximum for the water coming directly down the river. After this it fell slightly until April 6, when it began rising again from the water which had come through the crevasses above and was returning to the river by way of the Yazoo bottoms. This rise continued steadily until April 16, when a height of 52.5 feet was reached, which is 3.4 feet above that of 1890, the previous highest stage that is a matter of authentic record. On that date breaks occurred in the levee on the right bank of the river just below Vicksburg, which checked the rise and caused the water to fall very slowly. The water continued at practically 48 feet on the gauge, or above, from March 26 to May 22. How much above this maximum it would have gone had these breaks not occurred can not be definitely determined. The case is similar to that at Helena.

At Red River Landing the river reached its highest point on May 9, when the reading on the gauge was 50.18 feet, or 1.3 feet above the highest previous record of 1892. The Red River itself was about 20 feet below its maximum stage and falling when the Mississippi River was at its highest at this point.

At Carrollton the river reached its maximum stage on May 13, when the reading on the gauge was 19.05 feet. This is 1.60 feet above the highest previous record, which occurred June 22, 1893, and read 17.45 feet. The water reached this 1893 reading during the present flood on April 12, and remained at or above that height until May 31, a period of forty-nine days.

The crest of this flood wave passed Fort Jackson May 16, with a maximum reading on the gauge of 7.2 feet, or 0.3 feet higher than previous highest water of 1891.

From Red River Landing to New Orleans the levees remained practically intact, and the whole volume passing down the Atchafalaya flowed between its levees without loss.

The crest of this flood wave reached Cairo March 25, and arrived at Carrollton, La., just above New Orleans, May 13, 1897. A hydrograph has been prepared showing the stage at each gauge station below Cairo for the period from January to May, inclusive, 1897.

CREVASSES.

Lower St. Francis district.—This district comprises about 224 miles of projected levee lines, of which 115 miles have been constructed. During the flood 13 crevasses took place, having an aggregate length of about 13,405 feet, equal to 2.5 miles, or about 2 per cent of the constructed line.

This levee when completed will protect an area of 3,490 square miles. When the flood came against it, it was in a very incomplete condition, weak in section and wanting in height. The submerged area amounted to about 2,595 square miles.

Upper Yazoo Levee district.—This district contains 124 miles of levee, which protect about 3,280 square miles of territory. During the flood there was but one break in this line. This had a width of 2,067 feet, which is about 0.4 of a mile, or less than one-third of 1 per cent of the whole line. This break occurred at Flower Lake on April 4, and before it was closed about 342 square miles of country was inundated.

White River Levee district.—This district contains 64 miles of levee which protect an area of about 910 square miles. There were 14 breaks in this line during the flood, having an aggregate length of 16,400 feet, equal to 3 miles, or about 5 per cent of the whole line. These crevasses caused the inundation of practically the whole of this 910 square miles.

This line of levees was not up to the same grade as the levees of the Lower Yazoo district on the opposite side of the Mississippi River, nor were they in as good condition to withstand the flood, consequently when it came they gave way and relieved the pressure upon that side.

Lower Yazoo Levee district.—The levee lines of this district are continuous, and have a length of 186 miles. They cover an area of about 3,770 square miles. During the flood five crevasses took place. The aggregate width of these is 8,860 feet, equal to about 1⅔ miles, or only nine-tenths of 1 per cent of the whole levee line. Practically the whole of the covered area, 3,770 square miles, was inundated. The Deerfield crevasse occurred during a heavy windstorm and may have been caused by wave action. As far as known the other breaks were due to sloughs or defects in the body of the levee.

Upper Tensas Levee district.—There is a continuous line of levee 173 miles in length in this district, with a detached line of 12.4 miles. There were 1,030 square miles, 580 in Arkansas and 450 in Louisiana, inundated during this flood. Three crevasses occurred in the district, one near the upper end and two near the lower, aggregating in length 3,830 feet, about three-fourths of a mile or four-tenths of 1 per cent of the continuous line.

This system of levees being much below grade and of inferior construction in many places, it was not practicable with the emergency appliances at hand to prevent breaks and overtopping. A large quantity of the flood waters passed in around the upper end of the system.

Lower Tensas Levee district.—In the levees of this district, having a length of about 126 miles, but one break occurred, and that near the lower end at Glasscocks. It has a width of 1,400 feet. This crevasse was occasioned by weak profile and low grade at that point. Owing to the country being already under backwater passing in between the end of the levee and Red River, and from the outflow in the Upper Tensas district, no special damage was done by this crevasse. The area overflowed in this district amounts to about 2,020 square miles.

There were no breaks in the levees below the mouth of the Red River, excepting one at Conrads Point on the left bank about 6 miles below Baton Rouge. This occurred May 30, several days after the crest of the flood had passed and river had fallen 2.5 feet, and was caused by a system of crawfish holes connecting the river with a large pond behind the levee. It attained a width of 250 feet before it was closed. A large force began work upon it at once under the direction of the Pontchartrain levee board. The Mississippi Valley Railroad Company furnished gangs of skilled bridge carpenters; the planters furnished unskilled labor; the levee board the materials; and the United States the transportation, consisting of two tugboats and five large barges. The crevasse was closed June 6. The damage was slight and only local. Between the levees on the two banks of this portion of the river the whole of the flood, excepting that which passed down the Atchafalaya and Bayou La Fourche, found its way to the sea.

The discharge observations taken at Carrollton show that a larger quantity was passing down, and for a longer period of time than during any previous flood of which there is authentic record.

From the information now at hand it appears that there were approximately 1,377 miles of levees on the two banks of the Mississippi River between Cairo and the Head of the Passes; and that the recent flood caused breaks in these aggregating in length only 8.7 miles, which is about sixty-three one-hundredths of 1 per cent of the whole length of the lines.

These crevasses were all due inherently to low grades, weak profiles, or old, imperfect, or incomplete construction. None of the levees built by the United States was broken.

The total area of the overflowed land was about 10,667 square miles. A large part of this is not yet under the protection of the levee system, being regions at the lower ends of the great basins subject to overflow by back water, which would have been submerged had the crevasses not occurred.

That so small a percentage of these long lines of levees was destroyed, is due to the fact that during recent years they have been raised in many places to higher grades than formerly, and given stronger profiles; and that all authorities interested in them together with the citizens of each threatened locality, acted with great promptness in applying temporary expedients for preventing their destruction.

The district officers, and those acting under their instructions, are to be commended for the good judgment, activity, and energy displayed by them while executing their own work, and assisting the State authorities and local levee boards in their efforts to prevent the destruction of levees and save the lives and property of the people whose lands were submerged.

The $250,000 appropriated by joint resolution of Congress, approved March 31, 1897, was undoubtedly the means of preventing a much more extended destruction of the levees and a much more widespread inundation of valuable plantations. The Government steamboats, barges, and skiffs were largely used in carrying supplies to sufferers and transporting them and their property to places of safety. Detailed accounts of all these transactions are given in the several reports of the district officers herewith, to which reference is invited for further information.

The flood of 1897 has been a fruitful source of information to the Commission and to all those interested in the study of the hydraulics of the Mississippi River or the economic problems involved in the development of the resources of its lower valley. It has furnished much useful data that were needed in the solution of the problems involved in the proper control of the high waters of the river and the protection of the valuable agricultural lands along its borders. It has pointed out the weak places in the present system of levees and the defects in the methods of their construction. Better and more systematic planes of flood levels can now be established from Cairo to the Gulf than have heretofore been possible. The grade lines of levees can be established with some degree of assurance that they will not have to be raised within a few years, and the profiles can be determined for different localities with an equal degree of confidence. The district officers are now engaged in collecting the information bearing upon these points, and when this comes to hand the Commission will be better prepared than formerly to submit an estimate for the construction of a levee system that will give promise of a satisfactory control of all future floods. From the information now at hand it is believed that this estimate will not vary in any great degree in aggregate yardage from that given in the report of the Committee on Levees, to be found with the last annual report of the Commission. The amount there given as necessary to complete the system now adopted was 122,000,000 cubic yards. This, at an estimate of 15 cents per yard, would cost $18,300,000.

The important fact that the flood waters of the Mississippi River may be permanently controlled by a system of levees that can be constructed within a limit of expense warranted by the advantages to be gained seems to have been fairly demonstrated by the flood of 1897.

The Commission has been favored with valuable communications from H. N. Pharr, chief engineer, St. Francis levee board: T. G. Dabney, chief engineer, Yazoo-Mississippi Delta Levee district; William Starling, chief engineer, Mississippi Levee district; Henry B. Richardson, chief State engineer, Louisiana; and C. H. Purvis, chief engineer, Cotton Belt Levee district, giving results of their observations upon the flood of 1897, and their views and conclusions touching the efficiency of the levees as now constructed and contemplated, for controlling the flood waters of the river, and suggestions for improvement in the present methods of constructing levees. The information contained in these papers is of sufficient importance to warrant that they be forwarded for publication as appendices to this report.

Respectfully submitted.

G. L. GILLESPIE,
Colonel, Corps of Engineers, U. S. A.,
President Mississippi River Commission.
B. M. HARROD.
R. S. TAYLOR.
HENRY FLAD.
AMOS STICKNEY,
Lieutenant-Colonel of Engineers, U. S. A.
THOS. H. HANDBURY,
Major, Corps of Engineers, U. S. A.
HENRY L. MARINDIN,
Assistant, U. S. Coast and Geodetic Survey.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

Money statement.

Appropriations expended under Mississippi River Commission.

July 1, 1896, balance unexpended		$2,305,616.83
Amount appropriated by joint resolution (Public, No. 6) approved March 31, 1897	$250,000.00	
Amount appropriated by act of June 4, 1897	2,933,333.00	
		3,183,333.00
		5,488,949.83
June 30, 1897, amount expended during fiscal year		1,592,480.66
July 1, 1897, balance unexpended		3,896,469.17
July 1, 1897, outstanding liabilities	$103,921.35	
July 1, 1897, amount covered by uncompleted contracts	293,616.18	
		397,537.53
July 1, 1897, balance available		3,498,931.64

Distributed as follows:

Works above Cairo	$8,561.00
Mississippi River Commission	5,000.00
Surveys, gauges, and observations	25,065.78
Levees	86,786.13
Revetment and contraction works and permanent channel improvements	27,031.70
Dredges and dredging	40,000.00
Plant and miscellaneous	23,488.76
Improving harbors and tributaries	334,665.27
Unallotted	2,948,333.00
Total	3,498,931.64

Amounts that can be profitably expended by the Mississippi River Commission in the fiscal year ending June 30, 1899.

For improving Mississippi River from the Head of the Passes to the mouth of the Ohio River (as provided by act of June 3, 1896, modified by act of June 4, 1897)	$1,983,333.00
For improving harbor at—	
New Madrid, Mo	50,000.00
Memphis, Tenn	36,000.00
Helena, Ark	30,000.00
Greenville, Miss	100,000.00
Delta Point, La	150,000.00
Natchez, Miss., and Vidalia, La	317,000.00
New Orleans, La	300,000.00
For improvement at head of Atchafalaya and mouth of Red River, Louisiana	30,000.00

Consolidated statement of condition of appropriations and allotments, under Mississippi River Commission, on June 30, 1897.

[Appropriation: For improving Mississippi River.]

	Secretary Mississippi River Commission.				
	Mississippi River Commission.	Surveys, gauges and observations.	Dredges and dredging.	Patrol of the Mississippi River.	Total.
Amount expended on previous projects	$238,110.74	$855,247.37			$1,093,358.11
Amount expended on present project to end of last fiscal year	201,667.14	419,092.19	$34,229.58		654,988.91
Balance unexpended at end of last fiscal year	8,332.86	58,638.14	214,661.60		281,627.60
Amount expended from beginning of present fiscal year to end of previous month	30,235.30	60,999.54	a262,428.39	$463.52	354,121.75
Amount expended during the month	2,472.96	6,697.53	20,394.26		29,564.75
Balance unexpended at end of month	10,624.60	25,936.07	136,089.25	9,536.48	182,186.40
In Treasury United States	5,000.00	13,590.00	42,035.19	9,536.48	70,161.67
In hand	5,624.60	12,346.07	94,054.06		112,024.73
Total	10,624.60	25,936.07	136,089.25	9,536.48	182,186.40
Outstanding liabilities at end of month	5,624.60	9,936.07	49,833.05	592.04	65,985.76
Amount covered by existing contracts at end of month			46,256.20		46,256.20
Total	5,624.60	9,936.07	96,089.25	592.04	112,241.96
Balance available at end of month	5,000.00	16,000.00	40,000.00	8,944.44	69,944.44

[a] Does not include $1,964.81 expended by officer in charge of Fourth district, pursuant to resolution Mississippi River Commission, November 17, 1895 (Proceedings, p. 284).

Consolidated statement of condition of appropriations and allotments, etc.—Continued.

	Above Cairo.		
	Protection near Cairo. [a]	Des Moines Rapids to Ohio River.	Total.
Amount expended on previous projects	....	....	....
Amount unexpended on present project to end of last fiscal year	[b] $41,400.00	[c] $687,632.53	$729,032.53
Balance unexpended at end of last fiscal year	8,600.00	....	8,600.00
Amount expended from beginning of present fiscal year to end of previous month	....	....	....
Amount expended during the month	....	....	....
Balance unexpended at end of month	8,600.00	....	8,600.00
In Treasury United States	....	....	....
In hand	8,600.00	....	8,600.00
Total	8,600.00	....	8,600.00
Outstanding liabilities at end of month	39.00	....	39.00
Amount covered by existing contracts at end of month	....	....	....
Total	39.00	....	39.00
Balance available at end of month	8,561.00	....	8,561.00

[a] Includes only work under act of July 3, 1884.

[b] Amount previously reported reduced $10.85 on account sales and refundments prior to July 1, 1896.

[c] Des Moines Rapids to Illinois River, $207,663.38; Illinois River to Ohio River, $479,969.15. Amount previously reported reduced $271.74 on account sales and refundments prior to July 1, 1896.

FIRST AND SECOND DISTRICTS.

[Appropriations: Improving Mississippi River; improving harbor at Memphis, Tenn.]

	Surveys, gauges, and observations.	Lower St. Francis Levee district.	White River Levee district.	Upper Yazoo Levee district.	Plum Point Reach.
Amount expended on previous projects	....	....	....	....	....
Amount expended on present project to end of last fiscal year	$89,084.91	$333,941.45	$872,160.10	$774,847.68	$4,781,715.12
Balance unexpended at end of last fiscal year	5,088.20	11,260.55	21,649.50	25,254.10	115,945.50
Amount expended from beginning of present fiscal year to end of previous month	2,046.98	19,689.86	[a] 30,082.03	36,766.85	[b] 86,926.31
Amount expended during the month	115.77	1,066.03	515.22	5.39	14.76
Balance unexpended at end of month	2,925.45	[c] 8,942.16	[d] 4,489.75	16,606.86	4.43
In Treasury United States	....	....	....	....	....
In hand	2,925.45	8,942.16	4,489.75	16,606.86	4.43
Total	2,925.45	8,942.16	4,489.75	16,606.86	4.43
Outstanding liabilities at end of month	....	4,912.16	1,000.00	....	4.43
Amount covered by existing contracts at end of month	....	....	....	....	....
Total	....	4,942.16	1,000.00	....	4.43
Balance available at end of month	2,925.45	4,000.00	3,489.75	16,606.80	....

[a] Amount previously reported reduced 75 cents on account refund in December, 1896.

[b] Amount previously reported reduced $3.38 on account refund in October, 1896; $12.76 on account refund in November, 1896; 80 cents on account refund in December, 1896.

[c] $10,000 allotted by president Mississippi River Commission out of reserve from appropriation by joint resolution approved March 31, 1897.

[d] $5,000 allotted by president Mississippi River Commission out of reserve from appropriation by joint resolution approved March 31, 1897.

Consolidated statement of condition of appropriations and allotments, etc.—**Continued.**

FIRST AND SECOND DISTRICTS—Continued.

	Plant.	Removal Nonconnah Rock.	Preservation of works.	At New Madrid, Mo.
Amount expended on previous projects				
Amount expended on present project to end of last fiscal year	$603,936.55	$847.23	$22,972.26	$46,000.00
Balance unexpended at end of last fiscal year	68,086.84	5,152.77	40,895.63	
Amount expended from beginning of present fiscal year to end of previous month	*a*39,778.50	5,152.03	*b*31,873.04	14,827.02
Amount expended during the month	2,566.05			
Balance unexpended at end of month	34,418.88	.74	22.59	1,172.98
In Treasury United States	12,875.75		13.36	
In hand	21,543.13	.74	9.23	1,172.98
Total	34,418.88	.74	22.59	1,172.98
Outstanding liabilities at end of month	4,000.00	.74	6.59	
Amount covered by existing contracts at end of month	25,900.00			
Total	29,900.00	.74	6.59	
Balance available at end of month	4,518.88		16.00	1,172.98

	At Helena, Ark.	Improving harbor at Memphis, Tenn.	Expended allotments.	Total.
Amount expended on previous projects				
Amount expended on present project to end of last fiscal year	$75,010.00	$1,396,981.86	*c*$595,979.12	$9,593,476.28
Balance unexpended at end of last fiscal year	1,490.00	8,056.91	*d*63,011.70	360,891.70
Amount expended from beginning of present fiscal year to end of previous month	54,406.16	31,392.96		*e*352,941.74
Amount expended during the month	1,046.67	305.00		5,634.89
Balance unexpended at end of month	10,037.17	41,358.95		119,979.96
In Treasury United States		35,000.00		47,889.11
In hand	10,037.17	6,358.95		72,090.85
Total	10,037.17	41,358.95		119,979.96
Outstanding liabilities at end of month		100.00		10,053.92
Amount covered by existing contracts at end of month				25,900.00
Total		100.00		35,953.92
Balance available at end of month	10.087.17	41,258.95		84,026.04

---

a Amount previously reported reduced 75 cents on account refund in December, 1896; $7.50 on account refund of overpayment on voucher 1, Abstract B, April, 1897, accounts of Capt. Graham D. Fitch; $10 on account refund of overpayment on voucher 11, Abstract B, May, 1897, accounts of Capt. Graham D. Fitch.

b Amount previously reported reduced $2.50 on account refund of overpayment on voucher 2, Abstract C. March, 1897.

c Less $217,000, dredges and dredging, transferred to Secretary in January and February, 1896, and erroneously included in all statements for fiscal year 1896–97, under head of "Expended allotments."

d $62,210.11 transferred to Secretary July 27, 1896; $801.59 transferred to plant July, 1896.

e Amount previously reported reduced $38.44 on account above refundments.

Consolidated statement of condition of appropriations and allotments, etc.—Continued.

THIRD DISTRICT.

[Appropriations: Improving Mississippi River; improving harbor at Vicksburg, Miss.]

	Surveys, gauges, and observations.	Upper Tensas Levee district.	Lower Yazoo Levee district.	Lake Providence Reach.	Lake Bolivar Front.	Ashbrook Neck.
Amount expended on previous projects	....	....	....	....	....	....
Amount expended on present project to end of last fiscal year	$65, 199. 28	[a]$2,966, 185. 54	$1, 372, 307. 39	[b]$3,497, 175. 51	[c]$145,260.97	$415, 113. 59
Balance unexpended at end of last fiscal year	7, 730. 04	149, 972. 26	19, 635. 00	48, 147. 79	97. 07	35, 890. 28
Amount expended from beginning of present fiscal year to end of previous month	3, 086. 60	116, 335. 13	84, 528. 51	32, 300. 23	97. 07	18, 804. 95
Amount expended during the month	29. 80	6, 211. 11	1, 802. 85	365. 65	....	1, 075. 24
Balance unexpended at end of month	4, 613. 64	111, 176. 02	78, 303. 64	4, 481. 91	....	11, 010. 09
In Treasury United States	4, 000. 00	94, 750. 00	70, 000. 00	4, 000. 00	....	10, 000. 00
In hand	613. 64	16, 426. 02	8, 303. 64	481. 91	....	1, 010. 09
Total	4, 613. 64	111, 176. 02	78, 303. 64	4, 481. 91	....	11, 010. 09
Outstanding liabilities at end of month	1, 613. 64	11, 000. 00	4, 000. 00	2, 481. 91	....	1, 010. 09
Amount covered by existing contracts at end of month	....	91, 340. 00	67, 000. 00	....	....	....
Total	1, 613. 64	102, 340. 00	71, 000. 00	2, 481. 91	....	1, 010. 09
Balance available at end of month	3, 000. 00	8, 836. 02	7, 303. 64	2, 000. 00	....	10, 000. 00

	Stone.	Plant.	Preservation of works.	At Greenville, Miss.	Improving harbor at Vicksburg, Miss.	Total.
Amount expended on previous projects	....	....	....	....	....	....
Amount expended on present project to end of last fiscal year	$136, 044. 76	$580, 763. 92	....	$584, 245. 64	$576, 796. 21	[d] $10, 339, 092. 81
Balance unexpended at end of last fiscal year	23, 955. 24	5, 022. 79	....	2, 397. 38	6, 184. 77	299, 032. 62
Amount expended from beginning of present fiscal year to end of previous month	7, 338. 91	12, 851. 35	$29, 909. 02	19, 370. 69	3, 125. 72	322, 748. 18
Amount expended during the month	1, 584. 63	21. 00	[e]90. 98	....	87. 02	11, 268. 28
Balance unexpended at end of month	15, 031. 70	25. 44	....	47, 026. 69	2, 972. 03	274, 641. 16
In Treasury United States	15, 000. 00	....	....	40, 000. 00	....	237, 750. 00
In hand	31. 70	25. 44	....	7, 026. 69	2, 972. 03	36, 891. 16
Total	15, 031. 70	25. 44	....	47, 026. 69	2, 972. 03	274, 641. 16
Outstanding liabilities at end of month	....	....	....	....	972. 03	21, 077. 67
Amount covered by existing contracts at end of month	....	....	....	....	....	158, 340. 00
Total	....	....	....	....	972. 03	179, 417. 67
Balance available at end of month	15, 031. 70	25. 44	....	47, 026. 69	2, 000. 00	95, 223. 49

---

[a] Amount previously reported reduced $11. 24 on account sales and refundments prior to July 1, 1896.
[b] Amount previously reported reduced 223. 71 on account sales and refundments prior to July 1, 1896.
[c] Amount previously reported reduced . 04 on account sales and refundments prior to July 1, 1896.
[d] Amount previously reported reduced 234. 99 on account sales and refundments prior to July 1, 1896.
[e] $13.36 transferred to officer in charge first and second districts.

Consolidated statement of condition of appropriations and allotments, etc.—Continued.

FOURTH DISTRICT.

[Appropriations: Improving Mississippi River; improving harbor at Natches, Miss., and Vidalia, La.; improving harbor at New Orleans, La.; improving Atchafalaya and Red rivers, La.]

	Surveys, gauges, and observations.	Lower Tensas Levee district.	Atchafalaya Levee district.	Lafourche Levee district.	Barataria Levee district.
Amount expended on previous projects	....	....	....	....	....
Amount expended on present project to end of last fiscal year	$74,899.26	[a]$1,610,702.56	$907,309.12	$356,617.56	$196,329.51
Balance unexpended at end of last fiscal year	4,737.88	43,346.38	82,150.54	40,341.16	45,428.36
Amount expended from beginning of present fiscal year to end of previous month	1,311.71	44,339.49	98,233.54	42,433.49	32,018.10
Amount expended during the month	285.84	9,869.96	12,042.00	....	38.70
Balance unexpended at end of month	3,140.33	34,136.93	....	6,345.17	17,309.06
In Treasury United States	1,000.00	6,500.00	....	2,000.00	5,437.50
In hand	2,140.33	27,636.93	....	4,345.17	11,871.56
Total	3,140.33	34,136.93	....	6,345.17	17,309.06
Outstanding liabilities at end of month	....	250.00	....	....	80.00
Amount covered by existing contracts at end of month	....	33,886.93	....	5,860.04	1,829.23
Total	....	34,136.93	....	5,860.04	1,909.23
Balance available at end of month	3,140.33	....	....	485.13	15,399.83

	Pontchartrain Levee district.	Lake Borgne Levee district.	Dredges and dredging.	Plant.	Preservation of works.
Amount expended on previous projects	....	....	....	....	....
Amount expended on present project to end of last fiscal year	$729,475.81	[b]$182,200.59	....	....	....
Balance unexpended at end of last fiscal year	35,108.67	18,594.54	....	$10,000.00	....
Amount expended from beginning of present fiscal year to end of previous month	51,847.50	8,757.24	$1,964.81	....	$87,087.71
Amount expended during the month	2,775.46	....	....	....	22,835.93
Balance unexpended at end of month	2,985.71	14,337.30	....	10,000.00	24,076.36
In Treasury United States	500.00	8,500.00	....	10,000.00	....
In hand	2,485.71	5,837.30	....	....	24,076.36
Total	2,985.71	14,337.30	....	10,000.00	24,076.36
Outstanding liabilities at end of month	310.00	75.00	....	....	4,200.00
Amount covered by existing contracts at end of month	2,675.71	3,489.76	....	....	....
Total	2,985.71	3,564.76	....	....	4,200.00
Balance available at end of month	....	10,772.54	....	10,000.00	19,876.36

	Improving harbor at Natches, Miss., and Vidalia, La.	Improving harbor at New Orleans, La.	Improving Atchafalaya and Red rivers, Louisiana.	Total.
Amount expended on previous projects	....	....	....	....
Amount expended on present project to end of last fiscal year	$97,879.83	[c]$717,705.81	[d]$881,008.78	[e]$5,754,128.53
Balance unexpended at end of last fiscal year	70,372.21	10,684.55	55,700.62	[f]416,464.91

[a] Amount previously reported reduced $0.20 on account sales and refundments prior to July 1, 1896.

[b] Amount previously reported reduced 1.50 on account sales and refundments prior to July 1, 1896.

[c] Amount previously reported reduced 0.04 on account sales and refundments prior to July 1, 1896.

[d] Amount previously reported reduced 8.20 on account sales and refundments prior to July 1, 1896.

[e] Amount previously reported reduced 9.94 on account sales and refundments prior to July 1, 1896.

[f] Does not include $30,000 transferred from Homochitto Levee district to Lower Yazoo Levee district, October, 1896.

Consolidated statement of condition of appropriations and allotments, etc.—Continued.

FOURTH DISTRICT—Continued.

	Improving harbor at Natchez, Miss., and Vidalia, La.	Improving harbor at New Orleans, La.	Improving Atchafalaya and Red rivers, Louisiana.	Total.
Amount expended from beginning of present fiscal year to end of previous month	$23,561.40	$62,551.63	$12,410.47	$466,517.09
Amount expended during the month	1,281.64	225.62	328.83	49,683.98
Balance unexpended at end of month	109,529.17	57,907.30	82,961.32	362,728.65
In Treasury United States	109,000.00	50,000.00	80,500.00	273,437.50
In hand	529.17	7,907.30	2,461.32	89,291.15
Total	109,529.17	57,907.30	82,961.32	362,728.65
Outstanding liabilities at end of month	1,100.00	350.00	400.00	6,765.00
Amount covered by existing contracts at end of month	15,378.31	....	....	63,119.98
Total	16,478.31	350.00	400.00	69,884.98
Balance available at end of month	93,050.86	57,557.30	82,561.32	292,843.67

Consolidated statement of all appropriations expended under the Mississippi River Commission to June 30, 1897.

Act of June 28, 1879		$175,000.00
Act of June 16, 1880		150,000.00
Act of March 3, 1881		1,000,000.00
Act of March 3, 1881		150,000.00
Act of August 2, 1882		4,123,000.00
Act of August 7, 1882		150,000.00
Act of March 3, 1883		150,000.00
Act of January 19, 1884		1,000,000.00
Act of July 5, 1884		75,000.00
Act of July 5, 1884, less $5,000 transferred to snag-boat service		2,065,000.00
Act of July 7, 1884		75,000.00
Act of August 5, 1886, less $5,942.60 for expenses office Chief of Engineers		1,994,057.40
Act of August 5, 1886, less $47.30 for expenses office Chief of Engineers		29,952.70
Act of August 11, 1888, less $4,859 for expenses office Chief of Engineers		2,840,141.00
Act of August 11, 1888		75,000.00
Act of October 2, 1888		35,000.00
Act of October 19, 1888, deficiency, less $4,214.39 reverted to the Treasury		20,785.61
Act of September 19, 1890		3,200,000.00
Act of September 30, 1890, deficiency		5,625.00
Act of March 3, 1891, deficiency		1,950.00
Act of March 3, 1891		1,000,000.00
Act of July 13, 1892		2,470,000.00
Act of July 28, 1892, deficiency		44.80
Act of March 3, 1893		2,665,000.00
Act of August 17, 1894		485,000.00
Act of August 18, 1894		2,665,000.00
Act of March 2, 1895		2,665,000.00
Act of June 3, 1896		909,000.00
Joint resolution approved March 31, 1897 (Public, No. 6)		250,000.00
Act of June 4, 1897		2,933,333.00
Total specific appropriations		33,357,889.51
Balances from former appropriations applied to works below Cairo under act of August 2, 1882, less $123.42, reverted to Treasury	$272,504.96	
Same for works above Cairo, under act of July 5, 1884	22,632.53	
Total balances		295,137.49
Total		33,653,027.00

Consolidated statement of all appropriations expended under the Mississippi River Commission to June 30, 1897—Continued.

EXPENDED.

Location and object.	To June 30, 1896.	During year ending June 30, 1897.	Total.
Mississippi River Commission	$439, 777. 88	$32, 708. 26	$472, 486.
Surveys, gauges, and observations	1, 503, 523. 01	74, 573. 77	1, 578, 096.
Levees	10, 302, 077. 51	757, 168. 51	11, 059, 246.
Revetment and contraction works and permanent channel improvements	8, 999, 129. 44	162, 646. 41	9, 161, 775.
Dredges and dredging	422, 326. 70	284, 782. 46	707, 109.
Plant and miscellaneous	1, 184, 700. 47	55, 680. 42	1, 240, 380.
Improving harbors and tributaries	4, 583, 509. 63	224, 920. 83	4, 808, 430.
Works above Cairo	729, 032. 53		729, 032.
Total expended	28, 164, 077. 17	1, 592, 480. 66	29, 756, 557.
Balance unexpended June 30, 1897			918, 136.
Unallotted June 30, 1897			2, 948, 333.
Total appropriated			33, 653, 027.

LIST OF APPENDIXES TO REPORT OF THE MISSISSIPPI RIVER COMMISSION FOR TI FISCAL YEAR ENDING JUNE 30, 1897.

Appendix 1.

A paper by Lieut. Col. A. Stickney, Corps of Engineers, U. S. A., member Mississip River Commission, on plan of bank protection for the Mississippi River.

Appendix 2.

Letter of H. N. Pharr, chief engineer St. Francis Levee Board, giving his views to the lessons of the flood of 1897.

Appendix 3.

Letter of T. G. Dabney, chief engineer Yazoo-Mississippi Delta Levee district, gi ing his views as to the lessons of the flood of 1897.

Appendix 4.

Letter of William Starling, chief engineer Mississippi Levee district, giving l views as to the lessons of the flood of 1897.

Appendix 5.

Letter of Henry B. Richardson, chief State engineer, Louisiana, giving his views to the lessons of the flood of 1897.

Appendix 6.

Letter of C. H. Purvis, engineer Cotton Belt Levee district, giving his views as to t lessons of the flood of 1897.

Appendix 7.

Report of Capt. H. E. Waterman, Corps of Engineers, U. S. A., secretary Mississip River Commission.

A. Laws affecting the Mississippi River Commission.
B. Specifications for hydraulic dredges *Epsilon* and *Zeta*.
C. Report of Capt. H. E. Waterman, Corps of Engineers, U. S. A., upon dredgi operations on the Mississippi River between Cairo and Memphis during low-wat season of 1896.
D. Report of Assistant Engineer J. A. Ockerson on field work, office reduction a mapping, and on the construction, care, and repair of dredges.
E. Report of Assistant Engineer C. W. Sturtevant on location of dredge channels.

Appendix 8.

Report of Capt. G. D. Fitch, Corps of Engineers, U. S. A., upon operations in Fir and Second districts.

A. Report of Assistant Engineer A. J. Nolty on operations of construction parties at Plum Point Reach and New Madrid.
B. Report of Assistant Engineer William Gerig on work of improving harbor at Memphis, and construction work at Helena.
C. Report of Assistant Engineer Charles Levasseur on operations at Nonconnah Rock.

Appendix 9.

Report of Lieut. H. C. Newcomer, Corps of Engineers, U. S. A., upon operations in Third district.
A. Report of Assistant Engineer A. Hider on revetment work and plant.
B. Report of Assistant Engineer H. St. L. Coppee on levees in Arkansas above Greenville.
C. Report of Assistant Engineer E. C. Tollinger on levees in Arkansas and Mississippi below Greenville.
D. Report of Assistant Engineer J. D. Van Meter on levees in Mississippi above Greenville.
E. Report of Inspector L. Y. Kerr on levees in Mississippi below Greenville.
F. Tables of operations for high-water protection of levees, revetment work, labor statement of levee work, and United States expenditures for levees.

Appendix 10.

Report of Capt. G. McC. Derby, Corps of Engineers, U. S. A., upon operations in Fourth district.
A. Value of plant.
B. Commercial statistics.
C. List of civilian engineers.
D. Report of Assistant Engineer H. S. Douglas on Natchez and Vidalia harbors.
E. Report of Assistant Engineer H. S. Douglas on New Orleans Harbor.
F. Report of Assistant Engineer H. S. Douglas on repairs to plant.
G. Report of Assistant Engineer A. F. Woolley on Atchafalaya and Red rivers.
H. Report of Assistant Engineer A. F. Woolley on dredging Fords Crossing.
I. Report of Assistant Engineer W. J. Hardee on levees above New Orleans.
J. Report of Surveyor H. B. Watson on levees below New Orleans.
K. Abstract of proposals.

LIST OF PLATES ACCOMPANYING REPORT OF THE MISSISSIPPI RIVER COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1897, AND ITS APPENDIXES.

District map of Lower Mississippi River (1 sheet).
Maps and diagrams accompanying report of Lieut. Col. A. Stickney, Corps of Engineers, upon plan of bank protection (35 sheets).
Hydrographs accompanying letter of H. N. Pharr, chief engineer St. Francis Levee Board, on lessons of the flood of 1897 (10 sheets).
Plates accompanying annual report of Capt. H. E. Waterman, Corps of Engineers, secretary Mississippi River Commission: Maps and hydrograph pertaining to report on dredging operations on the Mississippi River between Cairo and Memphis during the low-water season of 1896 (10 sheets).
Hydrographs of the Mississippi River, Cairo to Fort Jackson; January to June, 1897 (1 sheet).
Maps and diagrams showing changes in bank lines and cross sections of the Mississippi, Vicksburg to Donaldsonville; 1882-83 and 1895-96 (16 sheets).
Plates accompanying annual report of Capt. G. D. Fitch, Corps of Engineers, in charge of First and Second districts:
Profiles of levees in Lower St. Francis, White River, and Upper Yazoo districts (3 sheets).
Maps of New Madrid and Helena fronts and vicinity of Memphis (3 sheets).
Map of Plum Point Reach (1 sheet).
Maps of Nonconnah Rock (2 sheets).
Map of First and Second districts, showing levees and overflowed area of 1897 (1 sheet).
Plates accompanying annual report of Lieut. H. C. Newcomer, Corps of Engineers, in charge of Third district:
Map of overflowed area in Third district (1 sheet).
Map of levee lines and crevasses of 1897 (1 sheet).
Profiles of high-water slopes in Upper Tensas and Lower Yazoo Levee districts (2 sheets).

Maps accompanying annual report of Capt. Geo. McC. Derby, Corps of Engineers, in charge of Fourth district:
Map of Natchez and Vidalia harbors showing Cowpen Neck (1 sheet).
Map of New Orleans Harbor (1 sheet).
Map of Fords Crossing showing dredged channel (1 sheet).
Map of levees in Fourth district (3 sheets).
Map of overflowed area in Fourth district, 1897 (1 sheet).

APPENDIX 1.

PAPER BY LIEUT. COL. AMOS STICKNEY, CORPS OF ENGINEERS, ON PLAN OF BANK PROTECTION FOR THE MISSISSIPPI RIVER, READ BEFORE THE MISSISSIPPI RIVER COMMISSION NOVEMBER 5, 1896.

ST. LOUIS, MO., *November 4, 1896.*

GENTLEMEN: Since the formation of the subconmittee, April, 1896, appointed to take into consideration the question of the possibility of devising a less costly form of bank protection than that now used on the Mississippi River, and for other purposes, I have given much personal study to the question of bank protection, which it seems to me is such a vital question in the accomplishment of the great work confided to the charge of the Commission, the permanent improvement of the Mississippi River. The result of my studies I desire to submit for your consideration.

For many years I have been convinced of the impracticability of protecting the banks of the Mississippi River for hundreds of miles by what is known as continuous revetment, and especially with the kind of revetment that has been placed on the banks of the Lower Mississippi River. The objections to this continuous revetment are, in my opinion, numerous and weighty, some of which are as follows:

1. The very great extent of the work, which requires the covering of almost every foot of caving bank for hundreds of miles.
2. The very great first cost of the work and the cost of maintenance.
3. The difficulty of watching and keeping in repair the long line of work hidden under the water.
4. The scant supply of some of the material used (brush), which can not be had in quantity sufficient for the work.
5. The probability that much of the revetment will be destroyed in a comparatively short time; that while it may remain serviceable for a greater or less period, it is subject to destruction at almost any time, and its failure may not be made manifest, or may escape observation, until its destruction has progressed to such an extent as to make repair equal to a duplication of the original work.

Holding these views, some years ago, while in charge of the fourth district of the Mississippi River, I studied the question, with the view of devising some better form of bank protection; and in 1884, with the approval of the Commission, built some structures in one of the bends of New Orleans Harbor, which were called submerged sloping spurs. This was a step in the direction of the conception of abandoning continuous revetment and holding only detached points of the bank. But in this experimental work the full idea was not developed, as the spurs were placed with the intention of preventing the cutting of any part of the bank by throwing the current outward at each spur and placing the succeeding spur at a point below, where the cutting current might be expected to return to the bank.

This placing of the successive spurs did not fully carry out the conception of holding detached points at considerable distances apart, leaving the bank between the points to be attacked by the current until it had receded to a position where its distance from the general flow of the river would be such that the velocity of flow along the retired bank, between the spurs, would be reduced below that necessary to erode the material of which the bank was formed.

In the project submitted to the Commission for the improvement of Natchez and Vidalia harbors in 1884, I proposed spurs in the bends 1,000 feet apart, while those in New Orleans Harbor were from 500 to 700 feet.

Even this was not the full development of the idea, which was to make the intervals between spurs from 3,000 to 4,000 feet, or about the width of the river between banks; but it was thought best to approach the new system by degrees.

The more recent study of the matter has led me to the belief that the intervals between fixed points of bank should be even greater yet—that is, from 7,000 to 8,000 feet—which would permit of the construction of much more substantial structures and yet reduce the cost per mile of bank.

THEORY OF THE PLAN.

Let us suppose that the banks of the river are firmly held above and down to a certain bend which it is desired to protect. According to the plan which I propose it would only be necessary to place structures for holding points in the bend at such distances from each other that the larger part of the flow of the river could not pass in and out between them. After passing a fixed point of bank under any given velocity the river could not turn sharply into the bank except by eddy action, but the downstream flow would turn on a curve and attack the bank below the fixed point, slightly at first, more vigorously as it got farther below the point. Now, with another fixed point below the first, the water must come out from the bend which it might make between the points. The question then arises, how far apart would the fixed points be placed so that they would fix a reasonable limit to the cutting back of the bank between them and not change the general direction of the river's flow. The farther apart the points could be placed, the less in number would be the structures and the less the cost.

An examination of the maps of the survey of the Mississippi River between Cairo and New Orleans reveals the fact that above the mouth of Red River there was, at the time of the survey, no bend in the river where the high-water concave bank had for any considerable distance a curve of much less radius than about 5,000 feet, except where chutes or divisions of the channel affected the flow, and a few cases where there were large escapes of water over the banks, which lowered the surface in the bends, or inflow of streams that disturbed the surface slope. Matthews Bend was an example of increased curvature due to lowering of bend surface, and an examination of more recent surveys shows that after the construction of a levee around the bend the curvature of the bend decreased and the opposite point was cut off.

There are 92 bends of considerable length where this limiting curve of about 5,000 feet radius was reached and but 14 where that curvature was exceeded; in all of the 14 cases there were local causes for excess of curvature. Lists are appended showing the location of the bends. A little consideration of the forces acting upon the water flowing in a curved channel of a sediment-bearing stream the banks of which are shaped by the cutting of the current shows that there must be, in all cases, a limit to the degree of bank curvature, beyond which the water will not flow along the concave bank with sufficient velocity to scour, and if the degree of curvature is considerably increased beyond this limit there will be but little flow along the concave bank, and there will be a deposit formed in front of the bank in such shape as to make a new bank having a sufficient radius of curvature to permit the water to flow along it.

It is a well-known fact that the surface of the water on the concave side of a bend in a flowing river is higher than on the convex side, due to the damming-up effect of the curved bank, and the greater the velocity of flow, or the sharper the curvature, the greater will be the difference of surface level of the two sides. This difference of level produces a tendency for the water to flow from the concave bank toward the convex bank. The living force stored up in the moving mass of water as it flows downstream produces a tendency for the water to move straight ahead on tangential lines, which causes it to impinge against the curved bank. The surface slope of the river downstream produces a tendency for the water to move along chords of the curve of the bank, they being the shortest paths, and therefore steepest slopes. Here, then, we have what might be considered three forces acting upon the water in different directions, all due of course to gravity. The relative intensities of these forces, together with the reaction of the bank, determines the direction of flow, and the intensities of the forces depend upon the velocity of the stream, the curvature of bank, the width of the stream, and the downstream slope. If the tangential force, as it may be termed, which causes the water to impinge against the concave bank, is sufficiently diverted from its course by the resultant force developed by the cross-river slope and the downstream slope, the attack on the bank becomes too feeble to cause scour, because the water is drawn away from it; and this happens when the bank is curved to a certain degree of curvature. The harder the material of the bank, the less need be the diversion of the tangential force to prevent scour.

Within certain limits of curvature, it is evident that the effect of the tangential force upon the bank increases as the curvature of the bank increases, because the attack becomes more direct, the water rubs harder, and the diverting forces produced by the downstream and cross-stream slopes are not considerable enough to produce much effect in drawing the water away from the bank; but as the curvature continues to increase the diverting forces increase more rapidly, and finally have so much effect upon the tangential force that the attack on the bank ceases altogether.

The limiting degree of curvature, when scouring ceases, will vary with the material of which the bank is composed, the velocity of the current, the width of the stream, and the downstream slope. The harder the material of the bank the greater will be its resistance to scour. The greater the velocity of the current the greater will be the tangential force of the water impinging against the bank, causing scour. The greater the downstream slope the greater will be the tendency of the water to flow on chords, thus deflecting the tangential force and lessening its effect on the bank. The greater the width of the stream the greater will be the divergence of the chord flow from tangents, thus making it more effective in deflecting the tangential force.

To summarize, I would say that in the comparison of two streams having sufficient velocity to move the material of the banks, that which had the greatest velocity, other things being equal, would have the sharpest bends; that having the softest banks, other things being equal, would have the sharpest bends; that having the least downstream slope, other things being equal, would have the sharpest bends; that having the least width, other things being equal, would have the sharpest bends.

From the above it would appear that the concave bank of a stream flowing in a curved channel becomes less stable as the curvature increases, until the curvature reaches a certain degree, and any increase of curvature beyond that makes the bank more stable.

The flowing of the water away from a sharply curved bank, or the chord flow, is well illustrated in plate 1, which gives the results of current observations recently made at one of the dikes on the Missouri River.

As heretofore stated, the maximum degree of curvature of concave banks in bends above the mouth of Red River, which are unaffected by division of channel or other causes of disturbance of slopes, has apparently a radius of about 5,000 feet. Below the mouth of Red River, where the width of river gradually becomes less, and the downstream surface slope much flatter, the maximum degree of curvature becomes greater, as for instance, in the bend opposite College Point, the radius is only about 3,300 feet, and opposite Algiers Point, in New Orleans Harbor, about 3,300 feet.

The fact that the river does not assume sharper bends is pretty strong proof that the forces under which the water is flowing act in such a way that sharper bends can not be cut out of the banks, except where other forces not usually acting are brought into play.

In confirmation of the assumption that 5,000 feet is about the least radius of curvature that bends above the mouth of the Red River will assume, where the flow is not affected by unusual forces, I would call attention to the bend opposite Craighead Point. Here the foot of the bend is firmly held by the Chickasaw Bluffs. The river passing from above Craighead Point is free to cut into the soft bank opposite the point to any degree of curvature that natural laws will permit. The bank is practically stable, with a curvature of about 5,000 feet radius, and there are evidences that as Craighead Point has worn away the opposite bend has followed it downstream with about the same curvature of bank. The shape of the bank at the Vicksburg cut-off is another example.

Another confirmation, as it appears to me, may be found in the contours and eddy line opposite Hopefield Point, shown in the survey of April, 1891, when the river was at a high stage. At that time the main river passing Hopefield Bend was flowing directly toward the Tennessee shore, but the entire body of water bent around to the right before reaching halfway to the left bank, its outer curve, as shown by the contours, having a radius of about 5,000 feet. The eddy line also has a radius of about 5,000 feet, though making a considerable angle with the contours, due, I presume, to the Wolf River current coming over the bar and acting on the surface of the main stream. (See plate 2.)

The more recent surveys of 1895 and 1896 (see plates 3 and 4), show that a bank line has formed from the middle of the river of 1891, opposite Hopefield Point, toward the Tennessee shore, with a curvature of nearly 5,000 feet radius, the radius being a trifle less and probably affected by Wolf River.

From the preceding I believe it safe to assume that if two points of a concave bank in a bend be made fixed points, the bank above the upper point being in a stable condition, the bank between the points will not recede by scour so far as to form a concave bend of much less radius than about 5,000 feet, except in the immediate vicinity of the lower point, where a great local increase of velocity and lowering of the bend surface might be expected, due to the passing of the contraction point, and a sharper curvature might be anticipated.

As to the application of the foregoing, let us assume a bend in a river 4,000 feet wide, the concave bank cutting under the action of the current. (See plate 7.)

By fixing the points A, B, C, the bank line between them might be expected to recede, but not beyond the curves shown, and from the evidence of the survey shown in plates 5 and 6, it is not believed that the thalweg would be much changed from its original position parallel to the original bank. It is assumed in laying down the curves that the curvature immediately above a point may have a radius as small as 1,000 feet, that the remainder of the concave curve will have a radius of about 5,000 feet, and that the convex part, just below a point, will have a radius varying with the general curvature of the bend, for it will be determined by the effect of the mid-river flow pressing the shore flow around the fixed point. The curve of 1,000 feet radius is taken from the shape of the bank in the Greenville Bend just above the upper spur in 1890, after the flood (see plate 8), but such excess in curvature, I believe, would not be found if the structure for fixing the point was of proper form.

The convex part of the curve is somewhat conjectural, and would have to be determined experimentally, but it is to be remarked that its radius might be considerably varied without making much change in the general shape of the bank below.

In fixing the distances between the points A, B, C, a maximum recession of bank of about 500 feet is allowed. Where that much recession is inadmissible, the fixed points must be nearer together.

To illustrate the matter upon an actual bend of the river, I have assumed certain fixed points on the bank of June, 1889, in the Greenville Bend, with what I believe might have been approximately the resulting bank line, if such points had been held. This line can be compared with the bank lines that were actually formed by the floods between 1889 and 1895. (See plate 8.)

STRUCTURES FOR HOLDING POINTS OF THE BANK.

If it may be admitted that the holding of properly selected, detached points of the bank would result, finally, in the stability of bank line, the question arises, How can points be held? What kind of structures can be built that can be reasonably expected to accomplish the desired purpose, and be permanent? In solving this problem it is first necessary to consider what are the causes tending to the destruction of any structure placed upon the banks of the river. These may be briefly stated to be, deterioration or decay of material of which the structure is built; direct scour of river bed in front of the structure, tending to undermine it; scour by eddy action produced by the structure itself; sliding of the bank on which the structure is placed; separation of the structure from the bank, by the river cutting behind it.

With adequate provision against these causes of destruction there would seem to be no reason why permanent structures might not be built.

In studying the question of a proper form of construction for a detached work for holding a point of bank line, I have made some investigations with regard to the falling of earthy material, under the supposition of scour at the toe of a slope, with the slope itself protected from scour. A mathematical determination was first made, the results of which are presented in the form of tables and diagrams. (See plate 9.) These mathematical determinations have been sufficiently verified by experiments to show that they are correct for material having an invariable slope. Of course where the slope varies, as it does in material not perfectly homogeneous, the recession of crest and advance of toe of the slope, change correspondingly.

It will be observed from the tables that a slope formed by the falling of material on its natural slope, after the removal of the material in front of successive vertical cuts at the toe, lies mostly in advance of a vertical plane passed through the initial line of cutting, the recession of the crest being very small.

After determining the position of various slopes, under various conditions of cutting at the toe, experiments were made on a small scale to determine how the advancing slope, formed by cutting at the toe, could be protected. Plate 10 shows the results of some of the experiments with stone broken in small fragments on a slope of sand. From these experiments it was found that the stone having a natural slope a little flatter than 1 on 1 would travel along the surface of a sand slope of 1 on 1.6, keeping the surface well covered, as long as stone was supplied at the head of the slope.

Surveys have been made at various dikes on the Missouri River. At one of the pile dikes a small submerged stone dike was placed in continuation of the pile structure, and repeated surveys made to observe the cutting action of the current. An examination was also made of a stone dike placed in the Missouri River opposite the city of St. Charles in 1884. These surveys are shown in plates 1, 5, 6, and 11 to 34, inclusive.

They had for their object the elucidation of a number of points presented in the problem under study, such as the angle between the general direction of flow of a stream and its shore line approach to a fixed point on a soft bank; the recession of the bank between fixed points; the direction of flow around a fixed point; the outer line of the eddy below the end of a dike; the manner in which a loose stone dike may be affected by the scouring of the bottom on which it rests.

The revetment and loose stone dike built by the Wabash Railroad Company to protect the bank above the bridge over the Missouri River at St. Charles (see plate 34), was constructed in 1884 and would therefore seem to be fairly permanent. But li exact information could be obtained as to the manner in which it was built.

The indications are that the scouring of the bottom in front of the dike of lo stone has reached its limit, and that limit is considerably above solid rock botto and the stone slopes remain practically as built, not having been added to since 18

The following conclusions were arrived at from the information obtained experiments on a small scale and the surveys on the Missouri River:

1. That if a sufficient thickness of stone is placed on the slope of the bank o river whose banks and bed are subject to scour, the subaqueous slope subsequen formed by scour will be formed almost entirely in advance of the toe of the origi slope, and the surface of it will be covered by the stone falling upon it.

2. That having reached the limit of maximum scour of the maximum flood, slope will become stable even on a soft bottom, probably due partly to the filling of the scoured bed after the flood velocities have moderated, and partly to enlarged cross-section.

3. That water flowing with a considerable current will pass around a fixed cu of 300 feet radius without producing any violent eddies.

4. That an angle of 30 degrees may be assumed, without serious error, as the c vergence of the shore line to the general direction of flow of the river immediat above a fixed point on a soft bank.

With these conclusions to guide me I have devised a structure which I beli would permanently fix a point of bank of the Mississippi River. And with a su cient number of such structures, properly placed, it is believed that the banks the river might be made stable at a comparatively moderate cost.

The plan of structure that I would propose is shown in plate 35, and also in model presented herewith.

This bank head, as I would call it, has a conical front, the least radius on horizontal plane being 300 feet, the deep water curves having nearly double t radius, and is built of piles, brush, stone, and earth, all wood for the perman structure being under water. The material thus placed might be considered in structible. The direct scour along the front would be provided for and kept fr undermining the structure by the large mass of loose stone which would fall on slope of earth produced by the scour, following it down, and keeping the line scour moving further out into the river as the bed deepened. This action is sho in plates 10 A to 10 K.

The formation of destructive eddies would, it is believed, be entirely prevented the form of the bank head, which would permit the water to flow easily around The sliding of the bank would be prevented by the flatness of the upper slope a by the retaining wall of brush and stone.

The separation of the bank head from the bank in rear it is believed could occur, as the easy flow of water around the extended front would prevent much o head forming above the structure and thus prevent any tendency for the water cut across the top of the bank; but if there should be such tendency developed top of the bank could be protected.

The bench between the upper and lower slopes is placed at about 10 feet abo low water so that by an inspection of the riprap front at ordinary low-water sta any need of additional stone could be easily ascertained and the stone prope placed.

The cost of one of these structures will, of course, vary with the locality in wh it is placed and the depth of water. The following estimate is based on the assum tions that the low-water surface is 40 feet below the top of the bank; that the lo water depth along the outer face of structure is 60 feet deep, and that suffici stone is provided to cover a subaqueous slope of 1 on 2 with 2.42 feet thickness stone, allowing for a scour of 100 feet in depth along the front. This, it is believ would allow for a structure of considerably greater magnitude and cost than m localities would require.

Estimate of cost of one bank head.

27,934 cubic yards stone in outer covering, at $1.50 per cubic yard	$41,901.
8,300 cords brush in outer wall, at $1.25 per cord	10,375.
158,000 square feet mat, at 2 cents	3,160.
7,518 feet piles, at 10 cents	751.
29,000 square feet wattling, at ½ cent	145.
Total	56,332.
7,731 cubic yards stone to cover bench and upper slope, at $1.50 (to be placed at a later date)	11,596.
Total	67,929.
20 per cent deducted for average structure	13,585.
Balance	54,343.

In the above estimate the cost of stone is taken at $1.50 per cubic yard. It is believed that if stone was delivered in large tows at one point, and cast from the barges as it would be in building a bank head, it could be procured for little more than $1 per cubic yard.

Assuming, however, the above cost of one bank head, and supposing a number of them to be placed at an average of 7,500 feet apart, the cost of protection would be about $7.25 per linear foot of bank.

Very respectfully, your obedient servant,

AMOS STICKNEY,
Lieutenant-Colonel of Engineers, U. S. A.,
Chairman Subcommittee.

To the SUBCOMMITTEE OF COMMITTEE ON CONSTRUCTION,
Mississippi River Commission.

List of bends on the Mississippi River having a radius of curvature of about 5,000 feet, located on survey charts, using latitude and longitude lines for coordinates.

Chart No.	Latitude.		Longitude.		Chart No.	Latitude.		Longitude.	
	°	′	°	′		°	′	°	′
4	36	49-51	89	0	29	34	23	90	44
4	36	47	89	06	29	34	21-22	90	46-46
5	36	36	89	10	30	34	13-14	90	55-56
5	36	34-35	89	11	31	34	9-10	90	49
6	36	34-35	89	16	31	34	12	90	49
7	36	31-32	89	25-26	31	34	10	90	56
8	36	27	89	27-28	31	34	09	[b] 90	58
8	36	35	89	29-30	31	34	08	90	57-58
8	36	27-28	89	32	32	33	58	90	58
8	36	26-27	89	33	35	33	50	91	03
9	36	22	89	29	36	33	40-41	91	02-03
9	36	24	89	29-30	36	33	41	91	03
9	36	22	89	34-35	36	33	40-41	91	09-10
9	36	21	89	36	36	[c] 33	43-44	91	10-12
10	36	16	89	33	38	33	27-26	91	13
10	36	15	89	41	38	33	30	91	09
13	35	54-55	89	38-39	38	33	27-26	91	08
13	35	52-53	89	44	39	33	27	91	04-06
12	35	54-56	89	44	39	33	27	91	08
14	35	51	89	42-43	40	33	20	91	11
14	35	48	89	48	40	33	19	91	11
15	35	46	89	53	41	33	09	91	10
16	35	40	89	50	42	32	58-59	91	14-13
17	[a] 35	30-31	89	56	44	32	44	91	07-06
19	35	17	90	10	44	32	45	91	10
20	35	15-16	90	09	45	32	39-40	91	10
20	35	10-12	90	06-07	45	32	37	91	07
21	35	09	90	03	48	32	20-21	90	57-58
21	35	05	90	06	48	32	20	90	54
21	35	07	90	10	49	32	16	90	58-57
21	35	08	90	07	49	32	13-14	91	03-02
22	35	01-02	90	12-13	50	32	07	91	05
22	35	01-02	90	17-18	51	32	06-05	91	03-04
22	35	00-01	90	18	51	32	05	91	07-08
23	34	56-57	90	15	53	31	51-50	91	13
25	34	45-46	90	25-26	54	31	46-45	91	21-22
25	34	44	90	29	54	31	46	91	16
26	34	38-39	90	28	54	31	45-48	91	24-23
26	24	38	90	29	55	31	37	91	25
26	34	40	90	34	55	31	38	91	29-28
26	34	37-38	90	35-36	55	31	36	91	25
27	34	34	90	32	56	31	31-32	91	30
28	34	25-26	90	34-33	57	31	24	91	33
28	34	24-25	90	37-38	58	31	21-22	91	33
28	34	22-23	90	38-39	59	31	17-16	91	37-38
29	34	22	90	40	59	31	11	91	36

[a] Above Fort Wright. [b] Above. [c] 2 bends.

List of bends in the Mississippi River, above mouth of Red River, having a radius of curvature of less than 5,000 feet; located on survey charts using latitude and longitude lines for coordinates.

Chart No.	Locality.	Latitude.		Longitude.	
		°	′	°	′
3	Birds Point Bend, below Cairo	36	59	89	07
4	At Chalk Bluff, below Columbus	36	43	89	06
37	Choctaw Bend	33	35	89	08
39	Spanish Moss Bend	33	24	91	13
41	Matthews Bend				
43	Below Skipwith Landing	32	57	91	04
43	Below Mayersville Landing	32	53	91	04
47	At Millikens Bend	32	28	91	05
47	Below Halpin Landing	32	27	91	01
48	Lower Nebraska Landing				
54	At Coles Point Bend	31	45	91	16
57	St. Catherines Bend	31	25	91	31
57	Ellis Cliffs	31	24	91	27
60	At Point Breeze Bend, above Fort Adams Landing	31	04	91	33

List of drawings accompanying Lieutenant-Colonel Stickney's paper on bank protection.

Plate 1. Dike 7. Gasconade Division, Missouri River. Paths of floats; showing tendency of flowing water to follow chords of sharp bends.

2–4. Bend opposite Hopefield Point, Ark., Mississippi River. Showing the formation of bank on Tennessee side of river by deposit outside of the curve of 5,000 feet radius, after the bank in Hopefield Bend was fixed by revetment. (From surveys of 1891, 1895, and 1896.)

5. Chamois Bend, Missouri River. Paths of floats. Showing position of thalweg chording the curve of retired part of bank, and slackened velocity of flow immediately along the retired bank.

6. Chamois Bend, Missouri River. Hydrographic chart.

7. Diagrams showing probable limits of recession of bank lines in bends of 15,000 and 8,000 feet radii, with detached points of bank firmly held by structures so built as to prevent eddies.

8. Bachelors Bend, Mississippi River. Same as plate 7 applied to an actual bend of the river.

9. Tables and diagrams showing the theoretical advance of toe and recession of crest, due to successive vertical cuts at toe of slopes of loose material having various natural slopes, the first cut being made from a horizontal plane.

10 A–10 K. Record of experiments, on a small scale, made on slopes of dry sand and crushed granite, showing changes in position of crest and foot, the action of stone in bulk in falling on sand slopes and the slipping of protecting mats, under the continued cutting and removal of sand at foot of slope or foot of protected area. Experimental Box.—Width, 24 inches; height, 16 inches; length, 36 inches. Sand sifted to pass through mesh of 30 parts to the inch. Crushed granite, fine particles removed and remainder passed through mesh of 8 parts to the inch.

10 A. Successive cuts of one-half inch on sand slope.

10 B. Successive cuts of one inch on sand slope.

10 C. Successive cuts of two-tenths inch on sand slope, at foot of protecting mat.

10 D. Successive cuts of one-half inch at foot of rock slope supported on bank of sand.

10 E. Successive cuts of one inch at foot of rock slope supported on bank of sand.

10 F. Successive cuts of one-tenth inch at foot of rock slope supported on bank of sand.

10 G. Variable cuts of one-half inch and 2 inches at foot of rock slope supported on bank of sand.

10 H. Variable cuts of one-tenth inch and one-half inch at foot of rock slope supported on bank of sand.

10 I. Variable cuts of one-half inch and one-tenth inch at foot of rock slope supported on bank of sand.

10 J. Variable cuts of one-tenth, two tenths, three-tenths, and five-tenths inch at foot of rock slope supported on bank of sand.

10 K. Successive cuts of one-half inch at foot of wedge-shaped section of rock supported on bank of sand.

11. Dike 16 A, Osage Division, Missouri River. Contours of river bed at end of pile dike and sections before adding a submerged stone dike extension; surveyed April 22, 1896.

12. The same as plate 11 after construction of submerged stone dike; surveyed May 2.

Plate 13. The same as plate 12, surveyed May 13–14. Showing scour.
14. The same as plate 12, surveyed July 13–14. Showing scour.
15. The same as plate 12, surveyed July 27–28. Showing scour.
16. The same as plate 12, surveyed August 21–22. Showing scour.
17. Hydrograph of Ewing Landing gauge covering the time of the surveys, April to September, 1896, also comparative cross sections on crest of submerged stone dike.
18. Dike 16 A, Osage Division, Missouri River. Paths of floats, showing current lines below extremity of dike, and the minimum radius of curved paths of floats which escaped the eddy; surveyed July 20, 1896.
19. The same as plate 18, surveyed July 20, 1896. Not printed.
20. The same as plate 18, surveyed July 21, 1896.
21. The same as plate 18, surveyed July 24, 1896.
22. The same as plate 18, surveyed July 24, 1896. Not printed.
23. The same as plate 18, surveyed July 24, 1896. Not printed.
24. The same as plate 18, surveyed July 28, 1896.
25. Dikes 7, 9, and 11, Gasconade Division, Missouri River. Hydrographic Chart, showing conformation of bank lines above, between, and below 3 permeable spur dikes.
26. Same dikes as plate 25, showing paths and velocities of floats.
27. Dikes 1, 3, and 5, Gasconade Division, Missouri River. Hydrographic chart, showing conformation of bank lines above, between, and below 3 permeable spur dikes.
28. Dike 1 of plate 27. Enlarged hydrographic chart and cross section at head of dike. Not printed.
29. Dike 3 of plate 27. Enlarged hydrographic chart and cross section at head of dike. Not printed.
30. Dike 5 of plate 27. Enlarged hydrographic chart and cross section at head of dike. Not printed.
31. Dike 7 of plate 25. Hydrographic chart and cross section at head of dike, showing on a larger scale the angle of bank approach and the eddy action immediately below a narrow spur pile dike.
32. Dike 9 of plate 25. Enlarged hydrographic chart and cross section at head of dike. Not printed.
33. Dikes 16 B, 16 A, and 17 A. Osage Division, Missouri River. Showing shore lines surveyed October 1, 1896, formed by a system of 3 permeable dikes, completed 1894.
34. Stone dike opposite St. Charles, Missouri River, built by the Wabash Railway Company, in 1884. Map of location and old shore lines, with sections, contours, etc., showing present condition. Surveyed September, 1896.
35. General plan of bank head, designed by Lieut. Col. Amos Stickney, for protecting caving banks of alluvial rivers.

APPENDIX 2.

LETTER OF MR. H. N. PHARR, CHIEF ENGINEER, ST. FRANCIS LEVEE BOARD, GIVING HIS VIEWS AS TO THE LESSONS OF THE FLOOD OF 1897.

OFFICE OF THE CHIEF ENGINEER,
ST. FRANCIS LEVEE BOARD,
West Memphis, Ark., May 26, 1897.

COLONEL: In an effort to comply with your request of the 21st ultimo, I have the honor to submit for the inspection of your honorable board a series of profiles of gauges to Helena. I find that I can not do justice to the subject in hand or treat it to my satisfaction with less than an exhaustive comparison of the relations of these gauges. You will observe that the plates are numbered from 0 to 8, inclusive.

I ask attention first to plate 0—profiles of Cairo, New Madrid, Cottonwood Point, Memphis, and Helena wave of 1896, which was strictly within banks from start to finish. It will be observed that from 19 to 26 feet the Helena curve lies closely with that of Cairo; at 26 feet it begins to diverge, and continues to do so at an increasing ratio until Cairo halts on March 27, when Helena is 1.5 feet below. There a sharp decline of 2.5 feet at Cairo gives but 0.2 foot at Helena, putting Helena 0.8 foot above Cairo. Thence to the crest of the second wave, the rate at Cairo exceeds that at Helena and puts Cairo again 0.7 foot above. In the last rise of 8.5 feet Cairo gained 1.5 feet on Helena. Had the wave been continuous, Cairo would have gone to 41 feet +, and Helena would have been 3 feet below.

This divergence of the two gauges is plainly shown on plate 1, gauges of 1897, where, when Cairo is 45 feet, Helena is 4 feet below, at 41 feet, while Memphis had not reached the outflow line, and no perceptible effect can be ascribed to outflow up to that stage. In a continuous rise this divergence of gauges invariably takes place somewhere between 24 and 36 feet. The more rapid the rise, the sooner it begins; the less rapid, the longer it is delayed.

The cause of this appears to be that a rapid rise gives a greater slope, a greater velocity, a greater elongation, and a greater depression. A less rapid rise diminishes these causes and effects, but no continuous wave, whatever its rate of rise at Cairo, can carry the Cairo gauge to Helena, if unmolested by extraneous influences. Short waves coming in quick succession can do it, provided they are repeated often enough (three or four times), but these need not be noticed, as they seldom reach the 40-foot mark, further than to suggest the error which necessarily follows from an effort to establish gauge relations from their gauge readings to be applied to maximum waves, which can not be produced in such quick succession. In a former paper I explained how these low but quickly succeeding waves destroyed normal gauge relations.

I ask particular attention to the profiles of the New Madrid, Cottonwood, Fulton, and Memphis gauges, plate 0, and respectfully submit that the New Madrid gauge governs the gauges from that point to Mhoons much more closely than the Cairo gauge, and gives results between these points, as shown by these gauge curves. This is plainly shown again by the profiles of these gauges on plate 1. The uniform relations which these curves hold to the New Madrid curve until that relation is destroyed by extraneous influences is interesting. Beginning on the 23d of February, Cairo time, New Madrid is 26.4 feet; Memphis is 24.4 feet, or 2 feet below. Thence for fifteen days, to the 10th of March, the ratio of rise between these two curves is so nearly unity that New Madrid has gained but 0.6 foot on Memphis. There New Madrid feels more sensibly the fall at Cairo and reduces its 2.6 foot lead to 1.5 feet on the 14th. The next two days they rose together 0.5 foot, at which point Memphis yielded to the outflow and abandoned New Madrid.

An examination of plate 2 will show at a glance how far the flood of 1897 exceeded all other great floods, as far as our records go, in magnitude, while it lacked nearly 0.6 foot of reaching at Cairo the highest known water, 52.17 feet, of 1883. Yet the volume of water far exceeded that of 1883 or any other year, the flood of 1883 remaining sixteen and one-half days above 48 feet on the gauge, while the 1897 flood remained forty days above that line, or the flood of 1883 was to the flood of 1897 as 16½ days are to 40. In addition to the maximum flood that passed Cairo, 1.1 feet of water fell along the whole Lower St. Francis front while the crest of the wave was passing, which was easily equal to 2 feet on the river or a gauge reading at Cairo of 53.6. (See meteorological map of Tennessee hereto attached.*)

As the flood of 1897 was probably the greatest that any man living to-day will ever see, it is sufficient for the near future to show what would have been its high-water line along the St. Francis front had that levee been completed and maintained, what would have been the gauge reading at Helena, and the probable results in the river below. The curves of plate 0 show so conclusively the gauge relations that exist along the St. Francis front, were that front closed, that it is unnecessary to discuss it further, more than to say that plate 0 presents the gauge curves of a maximum restrained flood with an average degree of adverse accident. There are no reasons why, if similarly restrained, a flood of 52 feet at Cairo should give other gauge relations than here shown. Plate 1 shows very much the same gauge relations between the shoal gauges as seen on plate 0 until New Madrid reaches 38.4 feet when Memphis was 37.1 feet, at which point Memphis went off, the outflow being so great as to take off all further rise at Cairo and to force the river down slowly at Memphis. Hence we see that the overflow exceeded in quantity the amount of water that passed Cairo above the 49-foot mark, or more than 2.6 feet of the crest of the wave, which equals about 5 per cent of the fluctuations, about 10 per cent of the volume, and about 20 per cent of the flow. Had this front been closed, I suggest that the Memphis curve would have followed the broken line indicated and reached 38 feet, possibly 38.5 feet. It could not have gone higher.

I wish now to ask your careful attention to the curve of the Mhoon gauge on this plate (1). You will observe how close and parallel to the New Madrid curve it lies, but below it, to 38 feet. There the New Madrid gauge, being more sensitive to the Cairo gauge, drops below Mhoons, but at once begins to converge toward and reaches it at 40.2 feet. There we see the unmistakable evidence of the superiority of the New Madrid curve compared to that of Mhoons. But just at that time (40.2 feet) Mhoons began to feel the return flow of the St. Francis, which gave 1.8 feet rise to that gauge. How much higher the St. Francis flood would have forced the Mhoon gauge had the Flower Lake and other levees in the vicinity held we can not know accurately. We may reason from the facts that the water in the lower part of the St. Francis Basin was estimated to be 4.1 feet above all former water marks, while near Flower Lake before the break, I am informed, it was 3.9. The further rise at Mhoons and Helena could not have been great. But this appears plain: Had there been no return flow from the St. Francis Basin, Mhoons would have, at 40.2 feet, resumed its place with and below New Madrid, and its position above indicates the volume and duration of the return flow.

---

* Omitted.

Examining the Helena curve on this plate (1), we see that it was on the 23d of February (Cairo time) 32.9 feet on the gauge and 0.4 foot above Cairo; that it crossed below Cairo at 35.8 feet, and took an increasing ratio of divergence from that curve. When at 40 feet, Cairo was 43.5 feet. When at 42 feet, Memphis was at 33 feet, the outflow line, and Cairo at 46.4 feet, or 4.2 feet above Helena. Up to this point there was no waste such as to materially affect the Helena gauge. The 1897 flood was restrained at this stage (46.4 feet) by levees for 20 miles below Fulton, where 33 feet is danger line. When Helena was at 44 feet, Cairo was 48.5 feet. This is the relation of the two gauges for all continuous floods up to the point of extraneous influences. Helena felt but slightly the decline of the 12th and 13th of March at Cairo which brought the Cairo curve too near to that of Helena to sustain it, hence Helena reduced its rate of rise and went off. Just then it began to receive the St. Francis flood which forced it up 2 feet above the normal stage due to the Cairo gauge. As to how much higher it would have risen if breaks had not occurred, see conclusions as to Mhoons gauge.

As to why the St. Francis flood gives this final abnormal maximum flood to the Helena gauge, see a former paper submitted to your honorable board.

Referring to plate 1 A, gauge curves of Cairo, Helena, Arkansas City, and Vicksburg flood of 1893, it will be observed that a secondary wave gave Cairo on the 15th of April 36 feet and in eight days carried that gauge to 43.8 feet. Being spent at that stage, the river fell to 41.8 feet, at which point the approach of the maximum of that year was felt and the rise continued to 49.3 feet. Not being sustained, as the late flood was, it, after nine days of maximum readings, fell rapidly.

The Helena curve begins on the same date (April 15) at 36.4 feet to 0.4 foot above Cairo, with an increasing ratio of divergence from that curve. At 38 feet Cairo was 40 feet, having 2 feet. At this stage the river was strictly within banks. This again proves my contention, heretofore set up, that no flood, however great, can transmit its gauge reading at Cairo to Helena if constrained to the channel. If the contrary should be asserted, then I ask at what point between 40 and 52 feet, Cairo gauge, will the Helena curve be reversed? And why? Comparing Helena on this plate and same on plate 1, we observe that the rate of rise at Cairo has much to do with the outflow into the St. Francis Basin. The flood of 1897 rose 16 feet in fourteen days. The increased inclination of flood plane thus produced gave such a velocity of current in the channel as to counteract very much lateral currents and prevent that congestion due to their existence. This is plainly seen in both the Memphis and Helena curves of 1897. The difference between the Helena curves of 1897 and 1893 is not due wholly to a difference of velocity by any means, for in 1893 the Point Pleasant-Bear Bayou levee was not built. That levee restrains a large volume of water to the channel, which affected materially both the Memphis and Helena curves. I inject this as a matter of interest rather than importance.

I have shown by curves of 1896 of Cairo, New Madrid, Cottonwood Point, Fulton, Memphis, and Helena (plate 0) the remarkable uniformity of relations existing between these gauges for a restrained flood, and contend that these relations would exist for all such floods; also, that the New Madrid curve governs all gauges below to Mhoons or all shoal gauges; also, that Helena takes an increasing ratio of divergence from and below the Cairo gauge up to the line of outflow, and contend that there are no reasons why the same relations should not continue under the same conditions. If this be true, closing the St. Francis front can not raise the water at Helena as high as to Cairo by from 2 to 4 feet, depending upon the rapidity of the rise at Cairo. A rapid rise will raise Helena less than a less rapid rise of equal height; also, that restrained floods are thereby very much reduced in duration. Therefore, for the protection of the levees below, the St. Francis front must be closed.

Plate 1 confirms my contention as to the relations existing between the Cairo and Helena curves. It also demonstrates the fact that the New Madrid curve governs those of the other shoal gauges, and shows the probable Memphis curve for 1897 (had the front been closed) at 38.5, as indicated.

Plate 1 A shows the curves of the pool gauges for 1893, when the St. Francis front was wholly open and the other large basins closed or practically closed. It shows distinctly the effect upon the Helena gauge of the vast outflow along the upper part of this front, which has since been closed; also the effect of the floods of the White and Arkansas rivers which came in or near the crest of that wave on the Arkansas City and Vickburg curves, raising them somewhat and extending them very much. I have indicated by a broken line the probable Helena curve for that year had this front been closed.

Plate 2 shows the Cairo gauge curves for four maximum floods. It will be observed how much 1897 exceeds all others.

Plate 3 shows the same for New Madrid. It will again be noticed how much 1897 exceeds the others.

Plate 4 shows the same for Fulton. It will be observed that the Fulton curves conform closely to those of Memphis, showing the same outflow and to about the same extent.

Plate 5 gives the gauge curves for Memphis for four maximum waves and indicates the Memphis curve for the late flood with this front closed.

Plate 6 gives the same for Helena. The return flow is plainly to be seen in each curve, giving to Helena at all times its highest water. This return flow, coming out at an elevation much higher than that due to the stage of water in the river—having been retarded in its progress through 200 miles by the innumerable objects in that basin that obstructed its flow and caused it to accumulate or dam up—raises the water on the Helena gauge 3 or 4 feet, increases the velocity and overtakes the receding flood in the river, and sustains it for weeks—after it should be in the Gulf of Mexico—against that system of levee, increasing the probability of disaster about in proportion to the square of the time in days.

An idea of the quantity of support given the flood in the lower river may be had by remembering that the area of the St. Francis Basin is about 5,000 square miles and that the average depth is about 8 feet. This is equal to a stream 1 mile wide, 40 feet deep, and 1,000 miles long. Flowing at the rate of 1,000,000 cubic feet per second, or an average mean velocity of 4.5 feet per second, it would take fourteen and one-fourth days to run out. This is very close to what in fact occurs. This basin, open, stands above the whole levee system below, a demon with Pandora's box in its hands.

Plate 7 shows gauge relations of Cairo-Helena and New Madrid-Memphis, repeated here to avoid the confusion incident to several lines grouped together.

Plate 8 shows the curves of the increments of the daily variations of the several gauges. The signs of the increments were observed in platting, with the result as shown.

If I am again asked why the outflow does not reduce the flood in the river equal to the rise given by its return flow—i. e., why one does not compensate for the other—my reply is that the outflow reduces the depth of water in the river, thereby reducing its velocity; also that the lateral currents induced by the outflow further impede the velocity. Suppose 350,000 feet per second outflow—equal to one-fifth of the whole volume—reduces the mean velocity but one-fourth. That will reduce the discharge one-fourth and sustain the flood height so far as to compensate finally for the outflow. Hence we see gauge curves do not indicate outflow except when in near proximity. Therefore when the basin has been filled and its flood reaches the mouth of the St. Francis, it does not find that its coming has been discounted. Hence it is able to give undue elevation to the Helena gauge.

As a final argument on the proposition that closing the St. Francis Basin can not raise the water at Helena under normal conditions much above its maximum reading previous to 1897, I here submit in tabular form the 0.′ elevation of the several gauges from Cairo south, the difference in elevation, the distance in miles, and the difference per mile, which shows that the rate of slope per mile increases from Cairo to Helena largely and with much uniformity, and that if the Cottonwood Point-New Madrid slope were produced to Cairo it would pass that gauge 18.98 feet above. This shows the Cairo pool. It is on this series of planes, increasing rapidly in inclination southward, that the flood is precipitated, and the velocities and discharges must bear some relation to those inclinations, other conditions being equal. And until it is shown that conditions are so unequal as to compensate for the difference in inclination of planes, we must insist that Helena will discharge more water than Cairo at the same gauge reading. If that be correct, the Helena gauge can not equal the Cairo gauge for the same flood, but, as we have heretofore shown, must be from 2 to 4 feet below.

While we have this table before us, let us see why there is such an accumulation of water in the lower river and why does it loiter there so long. The table shows that from Helena south the low-water planes are much less inclined, the average being 0.22 foot per mile, or, stopping at Baton Rouge in our comparison, 0.28 foot per mile, while from Cairo to Helena it is 0.42 foot. The high-water line approaches a uniform plane, but does not increase average slope.

It is plain that there is not slope enough between Helena and Vicksburg, where the depth of channel does not compensate for the want of it. From Memphis to Helena the slope is 0.547 foot per mile. From Helena to Vicksburg it is 0.327 foot, or a decrease of slope of 62.41 feet in a distance of 292.8 miles. This want of slope should be remedied. The remedy is to cut off three bends of the river, reducing its length more than 40 miles, thereby increasing the slope and reducing the high-water line along that reach of the river so far as to make their present levees sufficient for any flood. This increased velocity will remove the bars and improve the navigable conditions of the channel.

It will doubtless require a large sum of money to enlarge the levees on each side along that reach to such a grade line as the late flood has indicated.

These cut-offs and the necessary bank protections below each can be done probably for one-fourth the cost necessary to enlarge the levees, a million dollars be saved, and a vast amount of apprehension eliminated.

The late flood has been surpassed at Cairo by only two of record. The gauge of 1882 read 0.2 foot and that of 1883 0.57 foot higher, while no flood of record was sustained for such length of time or extent at that point. The excessive amount of rainfall along the Cairo-Helena reach and adjacent territory during the month of March, as the crest of the flood was approaching and passing, added very largely to the vast volume of water. That rainfall averaged about 12 inches over the entire State of Tennessee, being more than 10 inches at Memphis. It was this rainfall coming out of the Tennessee and Cumberland, close upon the 66-foot Cincinnati gauge of the Ohio, which checked the fall of the Ohio flood on the Cairo gauge and gave that gauge its maximum wave of 51.6 feet; the rainfall above noticed adding largely, as said, to the volume of water below Cairo. The restraint offered by the levees along the 66.5 miles, over which more than 95 per cent of the outflow into the St. Francis Basin had heretofore passed (see report of Mississippi River Commission of 1890), together with the rainfall, caused an elevation of the high-water line which appears to have culminated near Luxora, Ark., in a wave 4 feet above all former floods. Further instrumental examinations will show more accurately how it passed off.

I wish to call attention particularly to this: Ninety-five per cent of the outflow into the St. Francis Basin having been restrained by levees and the result in an exaggerated form seen, we know that the restraint of the 5 per cent of former outflows, not yet confined to the river, can not add much to the elevation of the flood line as established by the 1897 wave.

The velocity of current during the late flood, especially during the rising stage, was much greater than heretofore at the same stage. Further, there was a more general movement between banks—a much greater mean velocity—than heretofore observed. The rapid rise and great elevation it attained—the inclination of slope and volume of water accounts for this.

I have few suggestions to make as to levee construction. The specifications under which we are now building gives us a good levee and is costing us all we are able to pay. In the future other plans and specifications will doubtless be adopted, but any material change in specifications will add largely to the cost. Without such change, in locating, angles should be avoided and curves made so flat as to admit of a railroad track being operated on it. This would lead to a rock ballast of the crown and next to a rock revetment of the slopes, which would add very much to the permanency of levees. But at present we want levees—a defensive line from behind which we can check the progress of the enemy while we are perfecting this or building another of greater strength.

Respectfully submitted.

H. N. PHARR,
Chief Engineer Lower St. Francis Front.

Col. G. L. GILLESPIE,
Corps of Engineers,
President Mississippi River Commission.

Gauges of the Mississippi River.

[0 of gauge taken from record of 1895, Mississippi River Commission. High water is highest stage on record previous to 1897.]

Gauges.	Distance by river from Cairo.	Elevation above Cairo datum plane.	Distance between gauges.	Difference in elevation of gauges.	Average fall between gauges to the mile.	Average fall to the mile between Cairo and Helena, Ark.	Average fall to the mile between Helena and Carrollton, La.	Elevation of highest water above Cairo datum plane.	Difference in elevation of high-water marks.	Average fall of high-water line to the mile.	Average fall to mile from Cairo to Helena.	Average fall to mile from Helena to Carrollton, La.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Cairo	0	290.84						343.01				
Belmont	21.3	286.85	21.3	3.99	0.19			332.65	10.36	0.49		
New Madrid	70.3	275.75	49	11.18	.23			313.82	18.83	.39		
Cottonwood Point	123	250.62	52.7	25.10	.48			288.47	25.35	.48		
Fulton	175.4	228.55	52.4	22.07	.42			265.24	23.23	.44		
Memphis	230	203.97	54.6	24.58	.45			239.57	25.67	.47		
Mhoons	277.3	181.48	47.3	22.49	.48			221.68	17.89	.38		
Helena	306.5	161.98	29.2	19.50	.67	0.42		210.08	11.60	.40	0.43	
Sunflower	352.7	147.08	46.2	14.90	.32			190.08	20	.43		
Arkansas City	438.3	116.44	85.6	30.64	.36			166.74	23.34	.27		
Greenville	478.3	108	40	8.44	.21			152.30	14.44	.36		
Lake Providence	542.3	89.62	64	18.38	.30			131.52	20.88	.33		
Vicksburg	599.3	66.04	57	23.58	.41			115.09	16.43	.29		
St. Joseph	648.3	52.74	49	13.30	.27			97.89	17.20	.35		
Natchez	700.3	36.89	52	15.85	.30			85.49	12.40	.24		
Red River Landing	765.3	23.85	65	13.04	.20			72.72	12.77	.20		
Baton Rouge	833.3	20.06	68	3.79	.06			58.51	14.21	.21		
Carrollton	957	20.91	123.7	.85			0.22	38.36	20.15	.16		0.26
Mean Gulf level [a]		21.26		.35								

[a] Biloxi.

APPENDIX 3.

LETTER OF MR. T. G. DABNEY, CHIEF ENGINEER YAZOO-MISSISSIPPI DELTA LEVEE DISTRICT, GIVING HIS VIEWS AS TO THE LESSONS OF THE FLOOD OF 1897.

YAZOO-MISSISSIPPI DELTA LEVEE DISTRICT,
OFFICE CHIEF ENGINEER,
Clarksdale, Miss., May 22, 1897.

DEAR SIR: Responding to your letter of April 21, in which you request that I report for the information of the Mississippi River Commission my views and conclusions as to what has been demonstrated by the present flood in the Mississippi Valley touching the efficiency of the levees as constructed and contemplated, as a means to control the flood waters, and what changes, if any, in existing grades, cross sections, and general policy I would recommend, I have the honor to submit the following reflections and suggestions:

In 1882 the highest gauge reading at Cairo was 51.8 feet. At that time the St. Francis Basin was practically entirely unleveed, and the levees on the front of the Yazoo Basin offered little if any resistance to the free escape of the flood from the river channel. The White River and Lower Arkansas fronts were open also.

The effect of these conditions on the Helena gauge was a maximum reading of 47.2 feet.

In 1886 the Cairo gauge read 51 as the maximum. At that time the St. Francis front was open, and the Yazoo front had been closed. The White River Basin was also open. Under these conditions the flood height at Helena was 48.1 feet on the gauge.

In 1893 the maximum gauge reading at Cairo was 49.3. At that time the White River Basin had been partially closed, leaving a gap in the levee line of about 25 miles in the middle portion. This was the only modification of the general conditions affecting the Helena flood height, in comparison with those of 1886. The Helena gauge reading was 48.05 in 1893.

In 1897 the highest gauge reading at Cairo was 51.6 feet. The general conditions affecting the flood plane below were greatly modified since 1893. The escape of the flood water into the St. Francis Basin was largely prevented by a line of levee extending 115 miles from the upper end southward, covering something over half of the linear extent of basin frontage, and greatly more than half of the effective extent for flood escape. The result upon the flood elevation at Helena by these conditions was modified to an unknown degree by the breaks in the levee which occurred in this line. In addition to the above modifying causes, on April 4 occurred one break (Flower Lake) in the levee line on the Yazoo front almost exactly opposite the mouth of the St. Francis River, and two breaks a short distance below Helena on the right bank, the effect of which was to convert an energetic rise into a rapid fall of the flood plane at Helena. The highest gauge reading at Helena, which occurred on April 4, was 51.8 feet.

I had concluded from general observations that if the three breaks last mentioned had not occurred, the flood plane at Helena would have gone at least 1 foot higher. Major Starling, by a more exact process, using the rise after that date at the Iron Mountain Railroad crossing of the St. Francis River as a basis, and constructing a curve for Helena in analogy thereto, deduced the result that the Helena gauge would have risen to 53.2 feet had these breaks not occurred, which deduction I have no doubt is substantially correct.

To summarize results:

In 1882:	Feet.
Cairo	51.8
Helena	47.2
Difference	4.6

In 1886:	
Cairo	51
Helena	48.1
Difference	2.9

Which, as compared with a difference of 4.6 feet in 1882, shows a discrepancy of 1.7 feet, apparently due to closing the Yazoo Basin.

In 1893:	Feet
Cairo	49.3
Helena	48.05
Difference	1.25

Which shows a discrepancy as compared with 1886 of 1.65 feet, apparently due to the partial closure of the White River Basin.

In 1897:	Feet.
Cairo	51.6
Helena	*51.8
Do	†53 2
Difference	†+1.6

Which, accepting the "potential" flood height at Helena, shows a discrepancy of 4.5 feet as compared with 1886, apparently due to the complete closure of the White River Basin and partial closure of the St. Francis Basin; and as compared with 1882 a discrepancy of 6.2 feet, apparently due to the closure of the Yazoo Basin in addition to the White River and St. Francis basins.

If the St. Francis Levee line had remained intact, it is my opinion that the effect on the Helena gauge, as compared with complete closure of that basin, would have very nearly reached the ultimate result. This opinion is based upon the consideration that in 1886 the total increment from the "St. Francis wave" at Helena was 3 feet, which came out in four days' time. This was the result of the filling up of the entire reservoir space of the St. Francis Basin by the flood water which escaped from the channel of the Mississippi River, and the traversing of the entire length of that basin by the water which produced the 3 feet of increment at Helena. Furthermore, in 1886 the St. Francis water returned to the Mississippi River over the bank above the lower end of the basin to a distance above the lower end of perhaps one-fifth of its linear frontage, thus reducing the effective length of escaping frontage. In 1897 the escape of flood water below the terminus of the levee line would have filled a much diminished reservoir space and would have traversed a much reduced distance before returning to the main channel. I conclude, therefore, that taking the increment of the "St. Francis wave" in 1886 as a basis for comparison, that of 1897 would not have exceeded about 20 per cent of the former, or, say, 0.5 of a foot.

But the value of these reflections, for present purposes, is vitiated by the fact that numerous crevasses occurred at different times as the flood progressed in the levee line along the upper St. Francis front, which produced certain complications in the results on the flood plane below, the whole effects of which I have not the data, and probably not the ability, to estimate. It is my belief, however, that the crevasses on the St. Francis front did not modify to any extravagant degree the general results on the Helena stage. But the absence of these breaks would undoubtedly have exerted an important influence in raising the flood plane at Memphis and the upper end of the Yazoo Basin.

One very pronounced effect of the complete closure of the White River Basin front was the remarkably early date at which the flood plane reached an extraordinary elevation opposite its middle portion. On March 19 the Helena gauge reading was 47.7 feet, which exactly equaled the extreme height of the 1890 flood, while at Rescue Landing (339 L. below Cairo) at the same date the flood elevation was 3.2 feet above that of 1890.

As to the general effect of the closure of the White River front on the ultimate flood elevation, I will note the following facts: On section 87 of this levee line, being the junction of the Ward Lake levee with the front line (337 L. below Cairo), on March 20 the flood plane was 4 feet above that of 1890. At that juncture a crevasse occurred directly opposite, at Hugheys Landing, the effect of which was to lower the water here 0.5 of a foot. This was afterwards recovered and a further rise of 0.3 occurred. But from March 20 to April 4 the river at Helena rose 3.5 feet, and there seems no reason to suppose that this additional rise would not have extended to the point above described, except for the escape of the flood water into the White River Basin through a number of additional crevasses that occurred between those dates, as well as that at Hugheys above mentioned. Add to that the additional rise of 1.4 at Helena, which was prevented by the three crevasses on April 4, and the logical conclusion seems to be that the flood height on section 87 (337 L. below Cairo) would have been 8.9 feet above that of 1890.

The greatest actual relative flood elevation on the front of this levee district occurred on sections 80 and 81 (332–333 L. below Cairo), where the recent flood height was 5.6 feet above that of 1890 and 7.1 feet above the flood of 1882.

At Friars Point, 12 miles below the head of White River Basin, the present flood was 3.7 feet above that of 1890, which should have reached the further elevation of 5.1 above, had the breaks of April 4 not occurred. But the stage at Friars Point was further modified by other breaks which occurred in that vicinity before the date named above.

---

* Actual. † Potential.

From the foregoing facts and deductions it appears quite evident that a line of levees along the entire front of the White River Basin can not be maintained against any great flood unless very great additional strength is given it, and then only at the expense of the levees on the Mississippi side, unless equally great additions shall be made to their resisting power. It is also evident that the financial resources necessary to accomplish such colossal works are not likely to become available in the very near future. It would seem obvious, also, that as the White River Basin is largely a wilderness country that has never heretofore enjoyed protection against overflow and possesses very little resources of its own for the maintenance of levees it would be unwise at this time to attempt to levee that front, when such operation must necessarily involve great danger of destruction to old established lines of levee on the Mississippi side upon which many millions of dollars have been expended, and dependent upon which is a large and populous territory in a high state of development. I must confess that this looks like special pleading, but trust that on reflection such impression will disappear, in view of the "logic of the situation."

I should suppose, however, that both the upper and lower portions of the White River Basin could be afforded protection, as during some years in the past, and still permit the escape of such a volume of flood water through the intermediate part as will ameliorate the acute conditions produced by its complete closure until the levees on the Yazoo Basin front can be made strong enough to bear the additional burden which such closure must of necessity entail.

As regards the St. Francis Basin front, I do not know any sufficient grounds upon which to suggest that the existing extent of levee line should not be restored and perfected. But I believe it is obvious enough that great caution should be exercised in its further extension until the flood status is more clearly defined and established under existing conditions, and existing levees adjusted to meet those conditions.

In making the foregoing observations and suggestions I have necessarily been purely local in my applications, as my hands have been so full of my own concerns as to restrict my views to these limits, relying upon the other local engineers to piece out the problem, each for his own locality.

As to the best form of cross section for levees and method of building, my own practice, as the result of experience, is to make the river side slope 3 on 1 and the land side slope 4 on 1, with a crown width of 10 feet, which, in some very important pieces of levee of limited extent, I have made 12 feet. This is supplemented by a banquet on the land side with 40 feet crown, and a crown slope of 20 on 1, with a rear slope of 4 on 1. The banquet grade varies from 8 to 10 feet below levee grade, according to the height of the levee, the higher banquet grade being on the lower levee. I consider the above form of cross section as being about the economic limit, as regards cost and utility. I also attach great importance to making capacious excavations under new work and in old existing levees. The latter expedient I have not yet carried half far enough, as evidenced by the fact that all the crevasses I have ever had, including the recent one at Flower Lake, with a single exception, resulted from concealed defects in old levees. My present standard "Muck Ditch" is 12 feet wide at the top, 8 feet at the bottom, and usually 7.5 feet deep, but varying with developments in the character of material encountered. In the case of large and important levees I have made the excavation for foundation 20 feet wide and 10 feet deep, and have found them effectual against leakage under great pressure of water. I would prefer to make even more extensive excavations, except for the consideration of cost.

The question of grade lines must still, as heretofore, be largely controlled by the limitations of financial resources, as well as the further consideration that the ultimate flood elevation is still undeveloped. With the additional lights now before us, as the result of the recent flood, my own object will be to raise the grade lines of my levees, and other dimensions in proportion, as much as available means will admit of, with the certainty that several years must elapse, under the most favorable expectations, before we can be enabled to reach the ultimate condition of strength necessary to successfully resist the maximum strain under final conditions of flood control in the Mississippi River.

Trusting that I have covered the ground of your inquiries with sufficient fullness without too far exceeding the limits of the privilege which your courtesy has extended to me, I have the honor to be,

Very respectfully, your obedient servant,

T. G. DABNEY, *Chief Engineer,*
Yazoo-Mississippi Delta Levee District.

Col. G. L. GILLESPIE,
Corps of Engineers,
President Mississippi River Commission.

P. S.—In stating the flood-controlling conditions that existed in 1897, I omitted to note the complete closure of the White River front prior to this year and since 1893.

Respectfully,

T. G. DABNEY, *Chief Engineer, etc.*

APPENDIX 4.

LETTER OF MR. WM. STARLING, CHIEF ENGINEER, MISSISSIPPI LEVEE DISTRICT, GIVING HIS VIEWS AS TO THE LESSONS OF THE FLOOD OF 1897.

GREENVILLE, MISS., *May 27, 1897.*

COLONEL: In response to your request of the 21st of April last, I have the honor to report my views and conclusions as to what has been demonstrated by the flood of the present year touching the efficiency of the levees as constructed and contemplated as a means to control the flood waters, and also as to possible changes in grades, cross sections, and general policy.

The series of crevasses which have occurred on both sides of the river do not appear to me to militate at all against the efficiency of levees. When we attempt to control a great flood by means of embankments which we know to be too low, too weak and of defective construction, we must not be surprised if we encounter failure; nor does such failure present any valid argument against a system which contemplates sound and sufficient levees. I conceive it to be admissible that pure earthen dams may be built, without cores of masonry, puddle or other material, and of moderate dimensions, which shall hold 50 feet or more of water, provided a good foundation can be secured. Even without a good foundation it is evident that an embankment may be built which shall be safe against breaking, settling, or "blowing up" from beneath, provided ample dimensions can be secured. For instance, a levee a mile in thickness would hold 50 feet of water, even if built on sawdust. It might not be altogether secure against seepage under it, but it would not break. The only question, then, is as to the economical limits within which such a work can be built. This will depend on the considerations of grade and cross-section hereafter to be examined.

As to grades, it would appear that the flood line of this year affords a far better standard than we have ever had before. The first break in the levees of the St. Francis and White River fronts did not much affect any of the gauges below Helena, and did not affect that, probably, so much as 1 foot. It was not until the 28th of March, when the series of crevasses began which terminated, on the 4th of April, with the Flower Lake break, that the gauges below Helena were seriously affected, and at that time the river had attained a far greater height than ever before, and had been so closely confined that the normal relation between the different gauges was fairly well preserved. On the morning of the 28th of March, there was not a break from the mouth of White River to New Orleans.

We have the means of ascertaining with tolerable accuracy at the several stations, the height which the gauges would have attained had there been no breaks in the levees. The readings of the gauge at the bridge of the St. Louis, Iron Mountain and Southern Railway over the St. Francis River give us an indication of the probable height which would have been reached at Helena. The hydrographs of the two gauges are shown herewith. (See fig. 1.) It would thence appear that had it not been for the breaks on the 22d of March and subsequently 25 to 30 miles below Helena, the gauge at the latter point would have gone to 50 feet or a little more on the 25th of March, which is 0.6 foot higher than was actually recorded. Subsequently, on the 4th of April, after the beginning of the return flow from the St. Francis Basin, from the breaks at Caruthersville and elsewhere the Helena gauge went to 51.85, when it was checked by the breaks at Flower Lake and Williamsons. The river was then rising at the rate of 0.4 foot a day. It would have continued to rise for several days more, though not at the same rapid rate, for it rose at the Iron Mountain Bridge till the 5th of April. This station is about 200 miles above Helena by the bends of the St. Francis River and about 55 miles in a straight line. The time interval between the two places after the crevasses in the upper part of the basin was three or four days. Previous to that time it was zero. Doubtless the additional rise at Helena, had no further breaks occurred, would have been 1 foot or more. Add this quantity to the 0.6 due to the former breaks and we would have at least 53.4 as the gauge reading which would have prevailed at Helena if the levee systems as they existed had remained intact. What would have been the effect of completing the St. Francis system of levees to the mouth of that river may be a matter of controversy. In my opinion it would have made very little difference in the maximum gauge reading.

The reading of the Arkansas City gauge, in a confined river, when the White and Arkansas rivers are very low, corresponds pretty closely to that of the Helena gauge. At equal stages, near high water, Arkansas City passes about 20,000 cubic feet per second more than Helena. When the two tributaries are in flood the Arkansas City gauge, therefore, is the higher by the quantity due to the united discharges of the Arkansas and White rivers minus about 20,000 cubic feet. This year, at the time of highest water, the Jacksonport gauge, for three weeks, stood at an average of 24 feet and Little Rock at 15.9, which stages correspond, under ordinary circumstances, to discharges at Clarendon and Pine Bluff of about 100,000 and 80,000, respectively. Allowing for the reservoir influence of the basin, the two tributaries should have contributed to the Mississippi about 160,000 cubic feet per second, raising the river at

Arkansas City by the quantity due to 140,000, or about 2.8 feet above Helena. This should still be a little diminished for the reservoir effect of the main river between Helena and Arkansas City. Probably the Arkansas City gauge would have stood at about 56.

The highest point actually reached at Arkansas City was 51.9 feet on the 29th of March, the further upward progress of the river being abruptly checked by four great breaks in the levees of the Yazoo front. At that time there was a rise of about 2.3 still to come down from Helena, and there was a volume of water passing around the head of the Tensas levee system estimated at about 150,000 cubic feet per second, enough altogether to have brought the gauge at least 4 feet higher, or to 56 feet or more, as was estimated by the other method.

There is a normal difference at flood between Arkansas City and Greenville of almost exactly 5 feet, and between Arkansas City and Lake Providence of about 7 feet. Hence we should have had at Helena 53.4 feet, or 1.6 feet higher than actual high water; at Arkansas City 56 feet, or 4.1 feet higher than actual high water; at Greenville 51 feet, or 4.4 feet higher than actual high water; at Lake Providence 49 feet, or 4.6 feet higher than actual high water.

Along the front of this district, then, the actual flood line affords a nearly safe criterion, varying little from parallelism to the potential flood line, or that which would have existed in a confined river.

It is pretty evident that it will require a grade at least 4 or 4.5 feet above the actual high water of this year to hold a completely confined river. This allows no margin of safety at all.

These grades correspond very closely with those previously deduced for the flood of 1882, which was in this locality of almost exactly the same magnitude. This fact would seem to indicate that in fifteen years the flood line has not been lowered perceptibly by scour of the river bed.

In new levees, to the best of my knowledge, the standard cross section has proved itself sufficient so far as the embankment itself is concerned. Alarming symptoms of weakness have sometimes been revealed, however, in the natural soil under the levee. A striking example was afforded by the new work below Australia, which had been completed in 1895, but which had had no water against it until this year. Several large and threatening "boils," discharging considerable quantities of sand, broke out from 10 to 50 feet from the base of the levee, on the land side, and continued to run turbid water for several days. From the same cause (insufficiency of base for so weak a subsoil) very extensive and dangerous sloughs or slips occurred in the same vicinity. This part of the levee had no banquet. It is about 12 feet high. Where there was a banquet no trouble was experienced either with boils or sloughs. In places formerly distinguished by very large and ugly boils the difficulty has been entirely suppressed by the construction of banquets. In my opinion, no large levee should be built without them, unless it is evident that both levee and underground will be composed of the strongest soil; and where the material is very light the banquet should be placed 6 feet below the grade of the crown. In order to cover as much ground as possible, it should have a land slope not steeper than 1 on 5. I think, in accordance with the views of Mr. Arthur Hider, that the width of the banquet should be proportioned to the height of the levee. For a levee 14 feet high the crown of the banquet may be 20 feet; for a levee 20 feet high the width of the banquet may be 40 feet. The superior slope, or crown, of the banquet may drop 1 foot in 10. The width of ground covered will be in the one case 25 feet from the toe of the inner slope, in the other case 47 feet. The greater support, both against direct pressure against the levee and against upward thrust from soil water exerted on the berm, will thus be given to the higher and more dangerous embankment.

Says General Comstock: "What is really needed for levees is that the surface of the ground water as one follows it from the river side of the levee, at the high-water level, through the levee and the subjacent ground to the ground-water surface at some distance from the levee on the land side, shall everywhere be below the surface of the levee and of the adjacent ground." The same opinion is held by many engineers. With a view to the determination of the hydraulic gradient of the ground water, some experiments were made this year, under my direction, by Mr. G. G. Smith. Four well points, with tubing attached, were driven back of a levee about 11 feet high below Greenville, respectively, at the toe of the back slope and at distances of 50, 150, and 300 feet from the toe. The ground water rose in the pipes, which thus performed the office of piezometers. The heights attained in the pipes and by the external water are shown in the accompanying plot (see fig. 3), also the elevation of the natural surface. It will be seen that it would be difficult to build a levee which should satisfy General Comstock's requirements without inordinate expense.

Small levees may have a crown of 8 feet. For larger ones a crown of 10 or 12 feet is better. Side slopes, 1 on 3, except in situations much exposed to winds, or with large levees in light soils. In the former case the river slope may be 1 on 5, or even flatter. In the latter both slopes may sometimes be as much as 1 on 5. Wide crowns are very useful to build on in case of emergency. Large levees settle more than small ones and have to be "topped" more frequently and higher.

Levees built to these dimensions, with banquets, when constructed with proper care, even though the foundations be of weak soil, may be relied upon, I believe, to hold still water up to their very tops. My belief is founded upon experience. For storms a margin of safety of 2 or 3 feet will be required.

Now, what precautions are to be taken in the building of levees that they may be perfectly safe?

First, as to the foundation. Every care should be taken to remove foreign, especially perishable, material, and to insure a thorough union and incorporation of the new earth of the embankment with the natural soil under it. In the practice of the Dutch engineers the sod is carefully removed and stacked on one side, to be used afterwards in sodding the finished levee. The ground is then broken with a spade or plow, and the upturned soil chopped into fine fragments. The foot of each slope is marked by a trench at least 1 foot wide and deep, and parallel trenches of the same dimensions, and 3 feet apart, are dug lengthwise of the trace of the dike. All creeks, ditches, etc., falling within the limits of the work are carefully denuded of vegetable matter, their banks dug down to a slope of 1 on 2, and their beds filled and tamped, till the filling projects above the natural surface at least one-eighth of their depth under the same.

In construction the aim should be to make the bank as nearly as possible watertight. In Holland the earth is put up in layers, horizontal, lengthwise of the dike, and somewhat sloping in a transverse sense, toward the water side, for drainage and also to have the outer slope more closely compacted. (See fig. 2.) The same method has been recommended by Mr. Tollinger as an additional precaution against sloughing or slipping on the land side. The prescribed thickness is, for team work, 12 to 16 inches; for wheelbarrows from 8 to 12 inches, according to the nature of the soil. The earth is tamped, either by hand mauls or by horses. Usually there is one tamper to four shovelers.

The earth as put into the dike is assorted, so that the strongest material is worked into and adjacent to the front slope and the weakest into the body of the dike and the back slope. With sand dikes, and especially those which are badly exposed, there is a dressing or pitching of clay on the front slope, usually about 3 feet in thickness.

It used to be thought by many levee engineers that such refinements of practice were unnecessary, considering the great base which we give our levees; but it is believed that each year's experience, as our embankments are built higher and higher, as the interests protected by them become greater and greater, and as the results of crevasses are more and more disastrous, points to the advisability of increased care in construction.

It is undoubtedly desirable to keep the back slope of the levee dry, if it be possible within the limits prescribed by the conditions of the case. It is true that a wet or leaky levee does not seem to be much more liable to break than a dry one, so far as experience teaches. Wet earth will hold water if it can be kept in place; but a wet levee is likely to slough, and if it be necessary to top or repair such a work while the water stands high against it (as is very often the case) it is both inconvenient and dangerous for either teams or men to tread on a wet back slope. Wet earth, too, is likely to settle under no greater pressure than that of the workmen traveling over it. Any means, therefore, that can be rationally adopted without too great expense to accomplish this end ought to be welcomed by the engineer.

There are some soils, however, especially light, sandy loams, that will probably have wet spots in them in spite of all the measures that can be taken to keep them dry.

Many of the precautions mentioned above have been adopted by the engineers of the United States and of the local organizations in their practice; and, on the whole, levees are fairly well built under the present specifications. What appears to be a very good suggestion has been proposed by a very competent and experienced engineer, Mr. E. C. Tollinger, namely, the use of heavy rollers, as is customary in the construction of canal and reservoir embankments. It is thought that the tamping would thus be far more thoroughly performed than under the present system. It seems to be the general opinion that the layers might profitably be conformed in thickness to something like the Dutch standard. It appears to me, too, that surface breaking, under our present practice, is executed in a very perfunctory manner and that greater thoroughness in this respect is desirable.

It is to be observed that of the six breaks which occurred in the levees of the Yazoo front this year not one was in a new levee. Five crevasses took place in the district of which I have charge. Of the levees in which these occurred, four were built before the war and one in 1867-68.

It is well known that many or most of the older levees were built with an utter disregard of the precautions which we now look upon as indispensable. Up to a very late period the stumps of trees were cut down only level with the ground, and even this requirement was very laxly interpreted. No attempt was made at all to remove the lateral roots. Before the adoption of systematic methods of administration it was an ordinary practice to put whole logs into levees in cases of emergency as a cheap and ready means of construction. Embankments thus built were afterwards enlarged and adopted as part of the permanent line, and they constitute a considerable part of the system now in existence. It would have been far better to abandon them entirely or to have transplanted them, as was done by the engineers of the United States Government in Arkansas, but the local organizations were never able to afford this. They had to keep on patching and enlarging them till now these defective levees have grown to formidable proportions. They constitute about two-thirds of the whole line of this district.

The cheapest and best remedy that suggests itself is also the simplest. It is to give these old banks large additions of earth; both in front, to cut off some of the leaks, and behind, in the shape of banquets to act as buttresses and to keep them from "blowing up" from beneath. While the old levees are bad, they are not worthless. The large mass of earth in them possesses a considerable deal of strength. This year, after the river had fallen 2 or 3 feet from the highest point, the old levees seemed to be safe enough; at least, they stood and ceased to give any palpable ground for uneasiness.

A remarkable feature of this year's flood was the great number of sloughs that occurred. Most of these were in old levees with steep back slopes. It has frequently happened that a levee has been worn down from its original shape, or has settled till, instead of a crown of 8 feet and slopes of 1 on 3 it has a crown of 15 or 20 feet and slopes of 1 on 1. Now, in enlarging such a levee the new earth was given the usual slope of 1 on 3, and there was a hump, like that of an old-fashioned hip-roofed house on the back slope of the levee after enlargement. Most of the sloughs occurred in embankments of this type. They were generally arrested by bracing with brush and earth.

A notable exception to this rule was the new Australian levee previously referred to. Doubtless the cause of the very dangerous sloughs experienced here was the treacherous nature of the underground, which became very mobile, and ceased to afford a firm support to the bank resting on it. The bank itself, being built of the same kind of soil, became infiltrated with water and readily slipped down. These sloughs, too, were stopped and cured by bracing. The remedy suggested is more base.

The water was let, for the first time, against three new levees this year. Each of them settled considerably and sometimes so much as to excite serious alarm. The first was built in 1894-95, the second in 1895-96, and the third in 1896-97. The maximum settlement was probably something more than 1 foot. From the appearance of the earth about the grade stakes it is probable that the settling proceeded from the shrinkage of the earth in the levee more than from the sinking of the foundation. The same phenomenon has often occurred before, but the very high stage of the water this year rendered it particularly conspicuous and dangerous. The lesson which it teaches is that it is better to adopt the practice of the Louisiana engineers and let the water against a new levee before the time of extreme flood, so that the consequences of any accidents of shrinkage, sloughing, settling of the foundation, etc., may not be critical and so that there may be time to repair the damage if any occur.

The high water revealed, in a conspicuous manner, many inequalities in the grade. It always happens that the actual grade line departs more or less from the nominal line, and that even with adjacent stations one may be above and another below grade. This year, however, long stretches of a mile or more were found deficient by an average quantity of a foot or a foot and a half, when it is certain that they were built to gross grade only four or five years ago. Most of these levees are composed of strong black clay or "buckshot" earth. In the most conspicuous instances, the levee had not been traveled on or worn down in any way. It must therefore have shrunk in the bank or sunk bodily into the natural soil on which it rested. Such an event as the latter is not unknown. In this district several levees have sunk from 2 to 6 feet or more for considerable distances. This year the Vaucluse or "Whisky Chute" levee in Arkansas is said to have sunk about 1.5 feet.

So far as is known, such instances have been confined to levees built across the beds of old or recent watercourses. In situations of this kind a sinking of the body of the dike has long been recognized as an incident of levee practice. It is thought probable, however, that it may be more common than is usually supposed. A well-known Dutch engineer says, "The underground will be more or less compressed by the weight of the dike, until the resistance of the compressed soil is in equilibrium with the load. No precise limits can be fixed to such action, for the settling of the foundation depends upon the nature of the underground, the weight of the dike, and the extent of the surface over which the weight is distributed." It has appeared probable to some levee engineers of great experience, as, for instance, to Mr. Robert

Somerville, that a part of the loss of grade, which is so common with levees, especially those composed of and built on plastic clay, may be due to settling of the foundation as well as to "shrinkage" as understood in a technical sense. Levees are more liable to such incidents than other embankments because the ground on which they are built is subject to infiltration periodically by water.

A lesson which has been impressed upon those in charge of levees this year is the precariousness of "topping." This expedient had to be resorted to over great lengths of levee. In this district alone about 90 miles were raised from 1 to 3 feet. Usually the topping was performed by nailing horizontal plank to upright posts driven into the outer crown of the levee, and backing up the fence or wall thus constructed with earth, either loose or in sacks. In some instances, a sort of cofferdam was made by two parallel walls of planking filled in with earth. These contrivances answer very well for keeping out a few inches of water, but where the latter stands at a height of 2 feet or more against the topping there is apt to be dangerous leakage between the old and the new earth, resulting, in one instance, it is said (the Biggs Levee), in a crevasse. This levee had, previously to the topping, been enlarged on the land side, and this feature was thought to have added materially to the weakness of the topping.

Against severe windstorms topping is very vulnerable. The Deerfield break, in this district, is attributed to the washing away of the topping (which was of sacks) by a heavy gale on the night of the 28th of March, the overfall soon cutting the levee in two. Had the storm come from the west, instead of from the east, the levee above Greenville, which had been topped for several miles, would possibly have broken, and many other stretches would have been in imminent danger. The great series of breaks which occurred in 1882 is attributable to the violent storm of the 28th of February of that year, which swept away miles of topping and left the water free to pour over the levee.

Of the crevasses in this district, this year, one occurred from a storm, one from a slough, and three from weakness or defects in the underground.

Some progress has been made in the practice of closing breaks. Mr. T. G. Dabney's successful work in building 2,600 feet of pile and sack dike, part of it in 11 feet of water, will probably be described by him. In this district work was mostly confined to the stopping off of the deeper channels through the crevasses after the partial recession of the water. In two instances, the Sledge and Stokes breaks, brush dikes were built entirely around the crevasses, with the double intention of reducing the cross section of flow and of impeding the velocity. The dikes were little else than windrows of trees, carefully and systematically thrown together, so that the trees should fall one upon another and thus sink the dike to the bottom. At Stop Landing a different plan was pursued. The engineer in charge at that point, Mr. George C. Thomas, contrived to build a close and regular brush dike, composed of alternate layers of butts or logs, laid parallel to the trace of the dike, and fine brush laid perpendicular thereto. The work was continued till the dike was forced to the bottom. The structure thus built was very firm and strong, and I directed Mr. Thomas to complete it by throwing in front of the dike sacks filled with earth, thus shutting off the water entirely. The dike stood the additional strain very well, and a close dam was built 1,200 feet long, with a depth, for 800 feet, of 8 to 14 feet. At Deerfield and Promised Land the deep channels had a maximum depth of about 7½ and 10 feet, respectively, and the lengths of the pile and sack dikes were 820 and 600 feet.

Summing up the lessons of the flood, we have been taught:

1. To have held the present flood completely confined a grade (in this levee district) from 4 to 4.5 feet at least above the actual high water of 1897 would have been requisite, or from 2.8 to 4.1 feet above existing grades. This allows no margin of safety whatever.

2. The standard cross section of crown of 8 feet or more, side slopes of 1 on 3 and banquet for heights over 8 feet is sufficient for ordinary soils. For exceptionally weak soils special dimensions must be adopted.

3. The foundation must be carefully prepared, probably more carefully than is now the custom.

4. The levee should be so built as to keep tolerably dry if possible. It should therefore be put up in layers and preferably should be rolled.

5. Old levees can not be depended upon, not because of their age, but because they have not been properly constructed and are probably unsound. In enlarging such levees a greater volume of earth should be added than with new and sound levees. Banquets are specially indicated.

6. Steep back slopes are to be avoided, and especially such as present a hip or hump.

7. A more careful discrimination is necessary between soils than has heretofore been customary. A cross section which is safe with one is not necessarily safe with another. In building new levees in very light soils, banquets should be added, even with levees of 10 feet in height or less.

8. New levees are liable to shrink or settle or both when the water first comes

against them. Also alarming boils or sloughs may occur. It would be well, then, to let the water against them at comparatively low stages that opportunity may be given for repairs.

9. "Buckshot" levees can not be relied on to stand at grade. It would be well to build such banks higher than the ordinary grade. Levees across the beds of old water courses should always be built to high grade.

10. Topping is unsafe when the water stands high against it, especially in situations much exposed to winds. It is more than ordinarily dangerous when placed upon levees enlarged from the land side.

11. While it can not be said that the closing of large crevasses at extreme high water is practicable in any limited time, still under favorable circumstances the situation may be mitigated and relief given in many cases before it would have come from the natural recession of the water.

Very respectfully,

Wm. Starling,
Chief Engineer Mississippi Levee District.

Col. G. L. Gillespie,
Corps of Engineers,
President of the Mississippi River Commission.

Fig. 1.

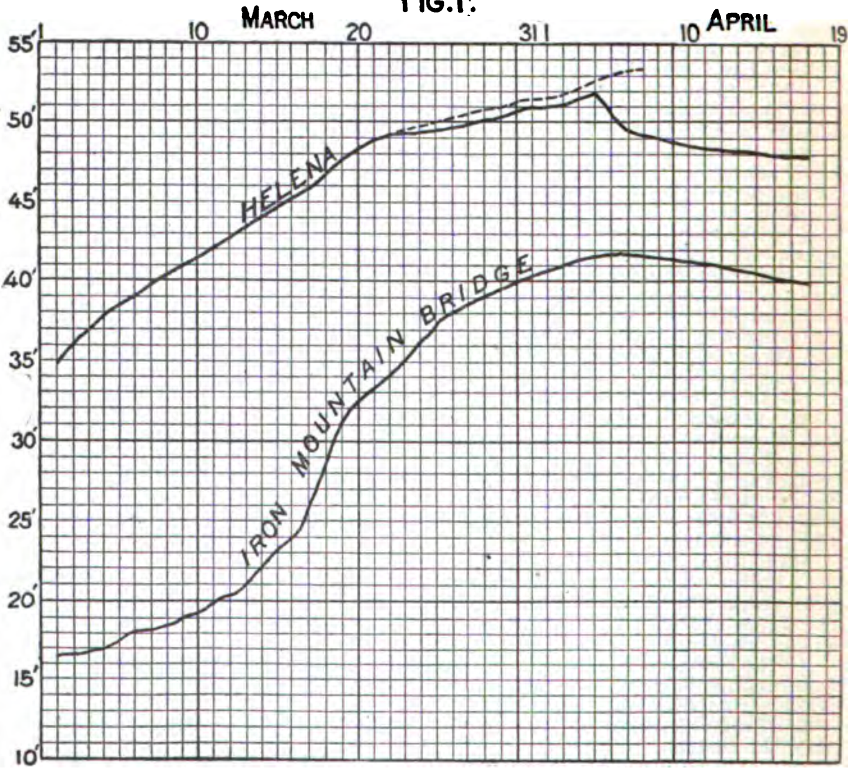
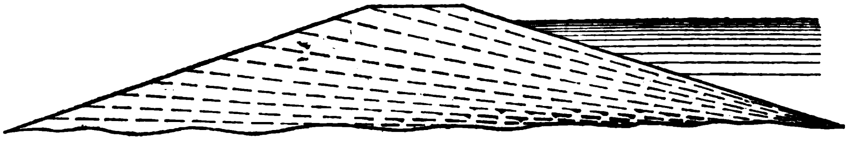


Fig. 2.



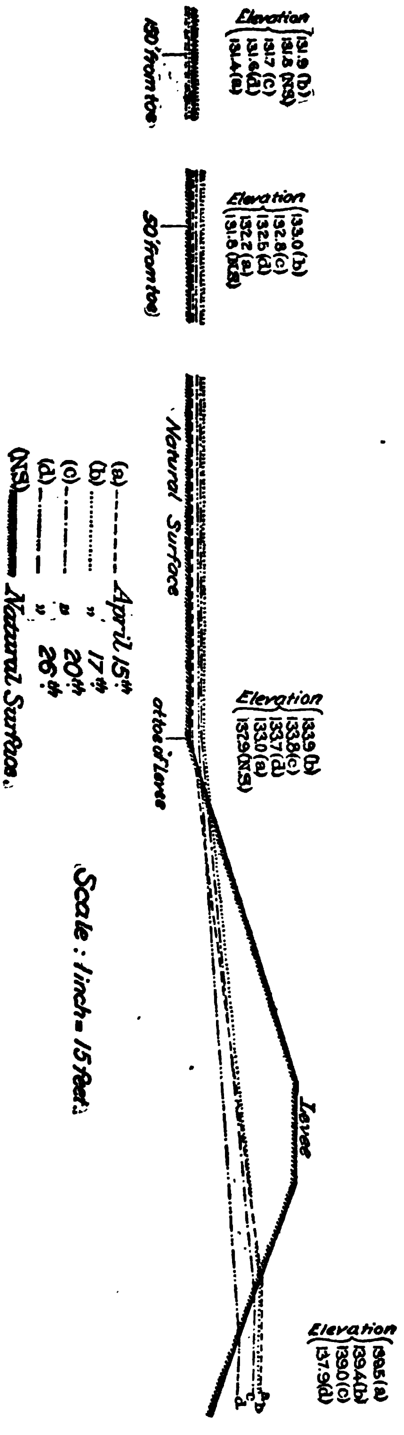

Elevation
131.9 (b)
131.8 (NS)
131.7 (c)
131.6 (d)
131.4 (a)
150' from toe
Elevation
133.0 (b)
132.8 (c)
132.5 (d)
132.2 (a)
131.6 (NS)
50' from toe
Natural Surface
at toe of Levee
Elevation
133.9 (b)
133.8 (c)
133.7 (d)
133.0 (a)
132.9 (NS)
Levee
Elevation
139.5 (a)
139.4 (b)
139.0 (c)
137.9 (d)
a
b
c
d
(a)------ April 15th
(b)........ " 17th
(c)-.-.-.- " 20th
(d)-..-..- " 26th
(NS) Natural Surface
Scale: 1 inch = 15 feet.

FIG. 3.

APPENDIX 5.

LETTER OF MR. HENRY B. RICHARDSON, CHIEF STATE ENGINEER LOUISIANA, GIVING HIS VIEWS AS TO THE LESSONS OF THE FLOOD OF 1897.

OFFICE BOARD STATE ENGINEERS,
New Orleans, La., June 3, 1897.

DEAR SIR: In compliance with the request contained in your letter of April 21st, ultimo, that I report for the information of the Mississippi River Commission my "views and conclusions as to what has been demonstrated by this flood touching the efficiency of the levees as constructed and contemplated as a means to control the flood waters, and what changes, if any," I would recommend "in existing grades, cross sections, and general policy," I have the honor to submit the following, premising that, except where otherwise stated, the levees referred to are those protecting the alluvial lands of the State of Louisiana:

EFFICIENCY OF THE LEVEES AS CONSTRUCTED.

The lines of levee upon the efficiency of which the low lands of Louisiana depend for direct protection against overflow by the flood waters of the Mississippi River extend, on the right bank, from Costello's gin, on Amos Bayou, Ark., to the Jump, near the Head of the Passes; and on the left bank from Baton Rouge to Bohemia.

On the right bank just previous to the present flood the line was continuous, except the outlet openings into the head of the Atchafalaya River and into Bayou Lafourche, and the gap of about 26 mile between Bougère Landing and the mouth of Red River, which has remained practically unleveed for the past thirty years. During this flood four crevasses occurred in this line, which have not been closed, all of them above the mouth of Red River.

On the left bank the line previous to the flood was unbroken and remained intact until the break at Conrad Point, May 30, when the crest of the flood had passed and the water had fallen some 2½ feet.

The present flood of the Mississippi River has also called into service the levees on the Atchafalaya River and on Bayous des Glaizes and Lafourche. Three small crevasses occurred on Bayou des Glaizes in a part of the line where the natural bank is so high that slight levees have been built there only upon the approach of high water, while there were three crevasses in the lower part of the levee system on Bayou Lafourche.

The total length of the levee lines above referred to is 816 miles on the Mississippi River and 256 miles on interior streams, an aggregate of 1,072 miles. The total width of crevasses is about 1 mile on the Mississippi River and less than three-fourths of a mile on interior streams, an aggregate of 1¾ miles; that is, 99.87 per cent of the levee line on the Mississippi River upon which Louisiana is directly dependent for protection and 99.71 per cent of the line in service this season on her interior streams, or 99.84 per cent of the aggregate, remains intact and is now as thoroughly efficient as it was before the flood.

The familiar saying, "A chain is no stronger than its weakest link," so often quoted in connection with levees, fails in application in many cases, and is especially inapplicable this season so far as levees protecting Louisiana are concerned. The broken links in this chain of levees have been so near its ends as to leave the body of the chain sound, strong, and efficient for the control of the flood. While the Biggs and Reid crevasses may be said to have broken one of the chains near its middle, producing overflow for 30 miles in a direct line above and for more than twice that distance below, it should be noted that all the others referred to, except that at Conrad Point, were so near the lower ends of the systems in which they occurred, or else on such high ground, that their effect was limited and local. The crevasses near the lower end of the levees on Bayou Lafourche have their outfalls almost at the edge of the sea marsh, and overflow but small areas of cultivable land, while those on Bayou des Glaizes and Amos Bayou were on comparatively high ridges, and their outlet capacity was insignificant. The crevasse at Glasscock's was so near the lower end of the Tensas Basin system that its overflow hardly added anything appreciable to the depth or area already overflowed by the water backing up through the unleveed front below Bougère Landing. The area of overflow caused by this unleveed front (Bougère to mouth of Red) was probably more than a third of the total area overflowed this season in the entire Tensas Basin, so that this large area would still have been inundated, even if the levees above Bougère Landing had continued absolutely efficient throughout the flood period.

The crevasse at Conrad Point is not far from the upper end of the Pontchartrain Basin, and had it happened at an earlier date, before the river began to decline, it might have flooded a considerably wider area than now seems probable. Its occurrence, after the river had been falling for two weeks, in a levee which had been maintained during all the time the flood was passing by in full volume, detracts nothing from the facts which show the general efficiency of the levees for the control of the flood in Louisiana, however disappointing it may be or injurious in its effects.

The area of the Pontchartrain, Lafourche, and Atchafalaya basins, lying wholly in Louisiana, and of the Tensas Basin, lying in Louisiana and Arkansas, as given on the "Map of the Alluvial Valley of the Mississippi River," published by the Mississippi River Commission, is 15,065 square miles, while the value of the taxable property, as shown by official tax rolls, is, in round figures, $180,000,000 in Louisiana alone. There can hardly be a reasonable doubt that nearly every acre of this vast territory would have been deluged by the great flood which has just passed down the Mississippi River had there been no levees to prevent. As a matter of fact, however, this flood was so efficiently controlled by levees that over 85 per cent of the gross area of these lands was completely protected from any overflow escaping through the crevasses of this season.

This estimated 85 per cent of gross area of course includes a vastly greater proportion than 85 per cent of the land open to cultivation. The lands cleared or opened for cultivation have naturally always been those on the highest ridges and least subject to overflow, so that any fair estimate of the cultivable lands overflowed by water from the crevasses which have occurred during the present flood must be but a small fraction of the total area flooded. For instance, in the parish of Tensas, which lies immediately below the Biggs and Reid crevasses, and over which all the water flowed which they discharged, it has been estimated by competent judges that not more than 22½ per cent of the cultivated land was overflowed this season.

Notwithstanding the fact that this flood reached much higher stages in the river than any previously recorded by nearly 3½ feet along some parts of the levee lines in Louisiana, and by over 2 feet against the major part of them, it is to be noted that every drop of it (except the insignificant volume escaping through the crevasses on Bayou des Glaizes) was successfully carried between levees from the head of the Atchafalaya Basin to the end of the levee systems near the Gulf. Not until two weeks after the flood had culminated, and it had fallen 2½ feet, was there any break in the levee or escape of flood waters through crevasses below the mouth of Red River on either the Mississippi or the Atchafalaya, and on Bayou Lafourche only after passing 40 miles down the stream between levees.

This flood was certainly held in complete control until two weeks after its crest had passed, in the Mississippi, from the head of the Atchafalaya to Bohemia, a distance of 257 miles; in the Atchafalaya, from its head to Melville, a distance of 35 miles; and in Bayou Lafourche, from its head to below the Southern Pacific Railway crossing, a distance of 40 miles.

This efficiency of control was partly due to the immense amount of labor and material expended by your executive officers, by the local levee boards, and by private parties, during the progress of the flood, for the protection and preservation of the levees. But the fact should not be lost sight of that the major part of the work thus done was applied to giving a greater margin of height to the existing line, and that while hundreds of miles of levees were raised with earth and planks or sacks, the water at the highest stage of the flood did not really touch but a very small proportion of this emergency work, although it could not have been foreseen that this would be the case. From this it plainly appears that these levee lines had a larger capacity for the control of this flood than that with which they were credited.

A system of levees that prevents overflow along 800 miles of river bank during such a flood as that now passing out of the water courses of the Mississippi Valley; that holds water 5 to 15 feet in depth, and often more, above the natural banks, and up to its very brim; that withstands the wear and strain of such a flood with a loss of only one-sixth of 1 per cent of its length; that absolutely protects 85 per cent of a territory containing an area of 15,000 square miles, and property values of $180,000,000, against complete inundation, inevitable without it; that subjects the entire volume of such a flood to absolute control throughout a length of 330 miles of leveed water courses. Such a system of levees surely can not be characterized as inefficient. Few great works or enterprises have achieved a greater degree of success, and probably none, while in the incomplete condition of the existing levee system of Louisiana.

GRADES, SECTIONS, ETC., CONTEMPLATED.

The general grade of the existing levees protecting Louisiana appears to have been barely high enough to hold the late flood along a large part of the line below the mouth of the Red River, and much of it between the mouths of the Red and Arkansas, at least along the upper part of the "Tensas front," would have proved insufficient but for the local depression in flood levels caused by the crevasses in Mississippi. The return of this crevasse water at the lower end of the Yazoo Basin, above Vicksburg, restored to the river its full flood volume, probably producing a higher stage in that vicinity than would have occurred had there been no crevasses in the levees on the "Yazoo front." The increment of flood stage at and near Vicksburg was limited—perhaps to some extent neutralized—by the Biggs and Reid crevasses just below. That a corresponding abnormal increase of flood stage did not manifest itself near the mouth of Red River upon the return of crevasse water at the foot of the Tensas Basin, is probably a phenomenon more apparent than real, and due to the fact that Red River failed to supply its usual flood contributions.

But whatever may be concluded as to the effect of the crevasse which occurred during the late flood, there can be no reasonable doubt that had its volume been swollen by such quantities of water as have frequently come down the Red and Arkansas in other flood years, the existing grade of the greater part of the whole levee line would have proved inadequate for efficient control.

The biennial report of the Louisiana board of State engineers of April 20, 1894, has the following statement, which still fairly expresses the attitude of that board as regards the subject of levee grades: "The truth is that so long as the height which will be reached by extreme floods when entirely confined between levees is not ascertained by actual experiment through a series of flood years, the final standard of height can only be provisionally determined."

The experience gained since the date above named has not given us sufficient data for final conclusions upon this all-important question. Nothing, however, has been developed by the late flood to impair confidence in the sufficiency of the grades proposed by your committee on levees, as stated in Appendix 4, page 3461, Report Mississippi River Commission, July 1, 1896. Practically this same grade was provisionally adopted by the Louisiana board of State engineers for levees below the head of Bayou Lafourche, as reported to the Mississippi River Commission in a letter of August 22, 1896 (a copy of which is appended hereto), and such work as has been done on these levees by the State and local levee boards since that date has been in general accordance with the grades therein described. At that date it was thought hardly feasible with the means available to undertake the general raising of levee grades above the head of Bayou Lafourche to a height greater than 5 feet above the plane of highest water of previous years. A better plane of reference, it is now considered, would be the high water of the late flood, and that a grade line 3 feet above the high-water plane of 1897 is a reasonable tentative standard to be worked to for the present; though on all parts of the line where 5 feet above previous high waters gives a higher grade, the latter is to be preferred.

As a matter of course, it would be better economy to build at once to the still higher grades contemplated in the report of your committee referred to, should it appear that the available means and the time requisite for executing the work would warrant such an undertaking.

As to the form of cross section best adapted to fulfill the purposes for which levees are designed, it can hardly be said that anything new has been demonstrated by the experience of this flood.

That form of embankment that will best retain its shape when completely saturated with water, still seems the best and safest. As the lower portions of a levee are generally less dry than the upper parts, there may be reason in giving the section flatter slopes toward the base than near the top; but generally speaking the form of section having a bench or "banquet" on the land side seems to serve all the purposes of a flattened slope, and indeed approaches the usual form naturally taken when it sloughs down and comes to rest in a position of stable equilibrium. Moreover, such banquets may generally be easily added to existing levees without the danger of serious sloughing during high water, which always in some degree attends the enlargement of a levee by adding to its comparatively steep land side face a thin wedge of earth, though of considerably flatter slope.

Levees built of almost any sort of earth with side slopes of 1 on 3 have generally stood without any sloughing of consequence, wherever the seepage water was well drained away from the base; but when drainage is deficient and also where the soil appears excessively loose and friable, the addition of a banquet, or construction with a flatter land side slope, is found to give stability.

The width of crown may properly vary according to the degree in which the levee is exposed to the washing of waves and with the friability of the soil, also to some extent, with the height; but in general, a width of 10 or 12 feet seems sufficient. The practice of raising the middle of the crown considerably above the edges has the advantage of shedding rain water promptly, and thus preventing the formation of gullies down the sides; but it is open to question whether it does not also somewhat retard the settling together and solidifying of the embankment which it is desirable to have take place as early as possible.

The proper allowance to be made for the settling or subsidence of embankments is a fruitful source of disagreement between engineers and contractors. The Louisiana practice for a number of years past has been to make it a matter of contract that a "net cubic yard of solid earth, equal to five-sixths of a gross cubic yard of loose earth," is the unit of measurement. This definition of the cubic yard was adopted at a time when most of the levee work was done with wheelbarrows, and there has been very little room for disagreements as to its meaning. But since the use of teams and scrapers has become general many contractors appear to think the requirement excessive. It has not been discovered, however, that any difference in the prices bid is made between work done under such a requirement and under those which only exact an excess of one-eighth or one-tenth over net measurements as an allowance. Hence it is thought that nothing could be gained to the public by changing this requirement to conform to the practice which appears to have become pretty general elsewhere. Levees built with scrapers certainly sometimes settle more than one-eighth, and if one-fifth in excess of the net measurements were always required levees would certainly be somewhat higher, and apparently at no cost to the public.

A few facts connected with levee construction and maintenance, though by no means new, may be mentioned as having been emphasized by the experience of this flood, such as the danger, more than ever apparent this season, that earth added to levees in enlarging them on the land side may slough and slide down during high water, or whenever it is first thoroughly saturated, even if that condition is delayed for years, and the consequent importance of placing all levee enlargements except that in form of "banquets" on the river side wherever practicable; the importance and value of good drainage as a means to prevent sloughing, and to dislodge or at least discourage the depredations of burrowing animals, and the fact that to stop leakage or excessive seepage—in fact, for almost any other purpose with which earth is added to levees—one spadeful of earth put on the water side of the levee is worth dozens placed on the land side.

The only recommendations I can make at this time are that gaps in the line be closed and the work of enlarging the levees throughout the alluvial valley to higher grades and stronger sections be carried on as rapidly as means therefor can be made available, and that in the interests of Louisiana the lines be extended up Amos Bayou in Arkansas, down the Mississippi, left bank, below Bohemia, and especially down the right bank below Bougère Landing.

Very respectfully,

HENRY B. RICHARDSON,
Chief State Engineer, Louisiana.

Col. G. L. GILLESPIE,
Corps of Engineers,
President Mississippi River Commission.

LETTER OF THE BOARD OF LOUISIANA STATE ENGINEERS.

NEW ORLEANS, LA., *August 22, 1896.*

GENTLEMEN: The board of State engineers proposes recommending to the boards of commissioners for the State levee districts in the lower part of Louisiana that the construction and enlargement of levees along the Mississippi River below the head of Bayou Lafourche be carried on as rapidly as the means available will permit, and that the top of the levees be fixed as nearly as practicable at a grade line (referred to the highest stages of water in the river thus far recorded) as follows:

Miles below Cairo.		Elevation of grade above high water.	Miles below Cairo.		Elevation of grade above high water.
From—	To—		From—	To—	
		Feet.			*Feet.*
885	892	5	964	973	3.9
892	899	4.9	973	982	3.8
899	906	4.8	982	991	3.7
906	913	4.7	991	1,000	3.6
913	920	4.6	1,000	1,009	3.5
920	927	4.5	1,009	1,018	3.4
927	934	4.4	1,018	1,027	3.3
934	941	4.3	1,027	1,036	3.2
941	948	4.2	1,036	1,045	3.1
948	955	4.1	1,045	and below.	3
955	964	4			

The reasons for adopting this grade are: (1) That there seems to be a reasonable prospect that it may give a margin of 1 or 2 feet above any future flood heights now considered probable; (2) that it appears practicable to obtain such grades with the means which should become available within a few years to come; and (3) especially that this grade is understood to be identical with that described or recommended in a report by your committee on levees.

Above the head of Bayou Lafourche it does not seem practicable at this time to undertake the construction or enlargement of levees in any general way to grades higher than 5 feet above the highest water recorded.

For the sake of uniformity it is respectfully suggested that the levee work of the United States in the Pontchartrain, Lafourche, Barataria, and Lake Borgne districts be made, as far as practicable with the means available, to conform to the grades above described.

Very respectfully, etc.,
THE BOARD OF STATE ENGINEERS,
Per HENRY B. RICHARDSON,
Chief State Engineer.

To the PRESIDENT AND MEMBERS OF THE MISSISSIPPI RIVER COMMISSION.

APPENDIX 6.

LETTER OF MR. C. H. PURVIS, ENGINEER, COTTON BELT LEVEE DISTRICT, GIVING HIS VIEWS AS TO THE LESSONS OF THE FLOOD OF 1897.

OFFICE OF COTTON BELT LEVEE DISTRICT,
Helena, Ark., June 17, 1897.

SIR: In answer to yours of April 21, 1897, I beg leave to state that notwithstanding the fact that the levees of the White River front were completely shattered by the recent flood (if you will recall my statement before the Commission last year, you will remember that I anticipated this result from the first water of any magnitude), I am more firmly convinced of the practicability of leveeing and controlling the Mississippi River than ever before.

My reasons for this statement are, first, the continued even ratio of rise between Cairo and Helena up to the breaking point of the St. Francis levees, where the effect of the outflow was felt by the Helena gauge four days afterwards. A study of a plat of the gauge readings for various years will, I think, show that Helena received the return flow from the St. Francis in a way experienced but once before, i. e., 1882, when the flood period at Cairo was of such continued duration that the St. Francis water with its accumulated height was enabled to again enter the river at Helena before the channel rise was affected by the Cairo fall, thus producing higher water than would otherwise have been possible under similar conditions—that is, with the then existing breaks in the White River front below Modoc. In other words, up to the time of the St. Francis breaks, and until the effect of the overflow below the St. Francis Levee was felt at Helena, the gauge relations of Cairo and Helena were practically maintained as existed below the 40-foot stage at Cairo, or when the river was entirely within its banks.

I can see no reason why the same flood line practically should not exist were the river completely leveed from Cairo to its mouth, which, if correct, would produce an extreme flood height of 54.9 at Helena, there being nearly 3 feet greater oscillation at Helena than Cairo, due to flatter slope. I think this elevation will continue to Wood Cottage (365 miles below Cairo), where, if the conditions which existed prior to the breaking of the levees prove anything, a very precipitate inclination occurs in the flood plane, producing by the time Henrico is reached an abnormal fall of about 4 feet. This condition is necessarily bound to continue until gradually restored by the flatter slope very much farther down the river. On March 11, by instrumental measurement, the river lacked but 4 feet of overtopping the levee at Wood Cottage; on that day there was no water against the levee at Henrico and no high banks intervening between it and the river. This levee is 12 feet high and 3 feet above former high water; the Wood Cottage Levee was also 3 feet above high water, which shows that on March 11 the river was within 1 foot of high water at Wood Cottage and 9 feet below at Henrico, 12 miles distance by levee, which shows that at that time there was 8 feet abnormal fall in that reach. This slope flattened somewhat, but never attained anything like a normal condition until after the breaks in our front permitted the water to reach Henrico by two routes, at the same time lessening the head in the channel. In this connection I desire to call your attention to the fact that at the Huntington place, 2 miles below Henrico by levee, the water in the river attained an elevation five-tenths above that reached at Henrico, bearing evidence of the immense volume of water carried by our breaks into White River.

As a further reason for believing in the efficacy of levees, I desire to state that I gave very considerable attention to the river itself during the flood, and can assert that the even distribution of the current over the entire river up to the time of the breaking of the levees was remarkable. There seemed no difference in its flow at any point. High bars were being washed away as well as projecting banks opposite, both sides of the towheads and islands were caving, and the river seemed determined to divest its channel of every obstruction and pile it on the banks. This I think good evidence that were the river leveed on both sides, it would produce a uniformity of channel attainable by no other method and ultimately almost entirely stop the caving.

As to levee dimensions, I am of the opinion that the dimensions used at present are sufficient in almost all cases, and would be entirely so if a banquet of suitable dimensions be built from 8 to 10 feet below high water, depending on the nature of the soil. I would suggest that after levees are built to an 8-foot crown with 3 to 1 slope, all dirt possible be piled on top, irrespective of slope. This will require only about 100 yards per station, and would produce about 3 feet additional height, of sufficient strength to hold a flood of short duration, and at the same time it would save the enormous cost of hurriedly raising a levee during a high water; as a precautionary measure of small cost, I do not think it can be equaled.

Very respectfully, yours,

C. H. PURVIS, *Engineer Levee District.*

Col. G. L. GILLESPIE,
Corps of Engineers,
President Mississippi River Commission.

APPENDIX 7.

REPORT OF CAPT. H. B. WATERMAN, CORPS OF ENGINEERS, SECRETARY MISSISSIPPI RIVER COMMISSION.

MISSISSIPPI RIVER COMMISSION,
OFFICE OF THE SECRETARY,
St. Louis, Mo., May 31, 1897.

COLONEL: I have the honor to submit the following annual report of operations under this office for the year ending May 25, 1897.

The work in charge of the secretary, Mississippi River Commission, during the past year has been carried on under allotments made by the Mississippi River Commission from the appropriations for improving Mississippi River between the Head of the Passes and the mouth of the Ohio, contained in the sundry civil bill approved March 2, 1895, and in the river and harbor bill which became a law June 3, 1896.

These allotments are as follows:

(*1*) *Mississippi River Commission.*—Available for salaries, clerical, office, and miscellaneous expenses of the Mississippi River Commission.

(*2*) *Surveys, gauges, and observations.*—Available for the survey of the Mississippi River between the Head of the Passes and its head waters, for the establishment and maintenance of gauges, for special surveys and examinations, and for the collection and reduction of physical data pertaining to the Mississippi River.

(*3*) *Dredges and dredging.*—Available for the construction and operation of dredges for the Mississippi River between Cairo and the Head of the Passes.

(*4*) *Patrol of the Mississippi River.*—Available for patrolling of the Mississippi River in time of flood for the saving of life and property. This is an emergency allotment made by the Mississippi River Commission at its sixty-ninth session, March 24, 1897, to cover expenses incurred in the extraordinary flood of the present year.

MISSISSIPPI RIVER COMMISSION.

The Mississippi River Commission has held six sessions during the past year, as follows:

Sixty-fourth session, June 16–22, 1896, at Army Building, New York City.
Sixty-fifth session, August 27–28, 1896, at Army Building, New York City.
Sixty-sixth session, October 7, 1896, at Army Building, New York City.
Sixty-seventh session, November 5–15, 1896, on steamer *Mississippi*, St. Louis, Mo., to New Orleans, La.

The various committees of the Commission have held the following special meetings since my last annual report:

Committee on dredges, September 25–26, 1896, on steamer *Search*, Cairo, Ill., to Memphis, Tenn.

Committee on levees, April 29–30, 1897, at St. Louis, Mo.

A board of officers, consisting of the district officers and secretary, met at St. Louis June 11, 1896, by order of the president, to report on the subject of a uniform system of monthly reports which would best conform to the requirements of Circular No. 2, Office Chief of Engineers, March 21, 1896.

Complete detail plans and specifications for new dredges have been prepared under the supervision of the committee on dredges. Plans for other plant needed in dredging operations have also been prepared at this office. An unusually large amount of office work and printing have been required in the preparation of reports, estimates, etc.

At the time of last year's report the steamer *Mississippi* was laid up at St. Louis, near the Carondelet docks. The work of painting the boat was in progress when the extraordinary cyclone of May 27, 1896, struck the city of St. Louis, but the only injury done to the boat was the disfiguring of the outside painting with the flying dirt and cinders. In the same storm five steamboats were sunk in the harbor and thirteen badly wrecked. The boat was repainted and fitted out with a new filtering apparatus. On August 25, 1896, the steamer was put in commission for temporary duty as a tender to the dredge *Alpha* and transferred to dredges and dredging. On October 25, 1896, she was relieved and ordered to St. Louis to prepare for the coming inspection trip. She arrived October 29, and left St. Louis with the Mississippi River Commission aboard November 5. She proceeded down the river, reaching New Orleans November 14, 1896. From this point a trip was made to Port Eads, La., and return, with the members of the Commission and the Board of Engineers, United States Army, on board. The steamer returned to St. Louis November 29, and on December 4 was again transferred temporarily to dredges and dredging and ordered to the lower river. She was finally relieved December 15, 1896, and laid up for the winter at East Cairo, Ky. On February 27, 1897, she was ordered to St. Louis to prepare for the spring Commission trip. A new mud drum was purchased and extensive repairs were made to the boilers and furnaces. The boat left St. Louis with the Commission March 24, 1897, reaching New Orleans March 31. She was utilized on the up trip for the purpose of special flood observations, reaching St. Louis April 16, and being laid up at the foot of Soper street on the 18th.

SURVEYS, GAUGES, AND OBSERVATIONS.

A complete history of the work of this character conducted by the Mississippi River Commission and its predecessors prior to May 25, 1896, will be found in the Annual Report of the Chief of Engineers for 1896, in part 6, pages 3575–3576.

Survey of the Mississippi River.—This survey, which is directed by law to extend from the Head of the Passes to the headwaters of the river, is being made with a view of obtaining sufficient data for accurate topographical and hydrographical maps, which may be used in studying the physical characteristics of the river and in planning improvement, and which may also serve as a basis for future surveys by means of which the changes in bed and banks may be ascertained and their causes and effects studied. It has therefore been carried on in the most thorough manner, using only the most approved methods. The field work consists of secondary triangulation, precise levels, topography, and hydrography. The limits of error allowed for the secondary triangulation work are well within the limits of those usually established for primary work. The methods used on this survey are fully explained in the Annual Report of the Chief of Engineers for 1891, part 6, pages 3474–3485.

As the secondary triangulation and the establishment of the stone line bench marks had been completed to Fort Snelling, Minn., the previous year, the work of the past season has consisted of the topography, contouring, and hydrography only. Owing to the high stage of the river for two months of the season the work was confined to the topography and levels along the bluffs and high ground. One hundred miles of river was covered between Arnolds Landing and Prairie du Chien before a suitable stage was reached by the river for the survey of the bars and lowlands. On July 26 the party turned back to Arnolds Landing and took up the hydrography and topography of the bottom lands and bars, which work was completed near Prairie du Chien by September 11; and from that time to the end of the season, which closed near Brownsville, Minn., on November 6, the topography and hydrography were carried along together.

It is found in practical experience that this plan of going over the ground twice does not materially increase the expense, and it does add very materially to the length of the season. Good results can only be obtained by surveying the river and its bars and lowlands at low stage; but, on the other hand, if the work is entirely confined to low-stage periods the season would be very short. It is also found that the high water makes easier of access the bluffs and high ground, so that this portion of the work can be more conveniently done at a high stage.

The topographical work now being done is in a very intricate country, the river being separated by a network of sloughs from the bluffs bounding the valley.

The field work of the season may be summarized as follows:

Main river surveyed, channel distance	miles	160
Topography	square miles	332.2
Hydrography	do	56.7

On November 7 the field party was disbanded at Lacrosse, Wis., the engineers being transferred to the secretary's office, where the work of reducing and platting the work and the season's notes was carried on during the winter.

The steamer *Patrol*, the survey boat *Illinois*, and fuel barges were put into winter quarters at Lansing, Iowa.

The survey of the river was resumed May 20, 1897, at the upper limit of the work of 1896, near Brownsville, Minn. (751 miles above Cairo). The organization of the party and the plant and methods used are practically the same as last season. The river being now at a high stage the survey will be confined to the bluffs and lands above overflow until such time as the stage is favorable for hydrography and surveys of the bars and lowlands.

Gauges.—The permanent gauges of the Mississippi River Commission (14 on the Mississippi, 1 on the St. Francis, and 1 on the White River) have been maintained throughout the past year. They have been inspected by a party on the steamer *Search* three different times during the past year. Necessary repairs were made to the gauges and bulletins at each inspection. No material change has been made in the location of any of these gauges except that at Mhoons Landing, which was moved upstream about 325 meters on account of caving banks.

The importance of frequent inspection of the gauges can not be too strongly emphasized. It is believed that the small corrections to the observers' gauge readings required during the past year may be fairly credited to the increased number of these inspections.

In this connection I would renew the recommendations of previous secretaries that all gauges on the Lower Mississippi River be placed under the control of the Mississippi River Commission. Many of these gauges are now maintained separately by the Engineer Department under the permanent appropriation authorized by the act of February 21, 1871. A history of these United States Engineer gauges will be found in the Annual Report of the Chief of Engineers for 1896, part 3, pages 1633–1638, the officer in charge being Maj. Joseph H. Willard, Corps of Engineers, United States Army. In the Annual Report of the Chief of Engineers for 1888, page 1373, Captain (now Major) Willard states:

"Reports are received at this office weekly, and after review are consolidated and sent to the secretary of the Mississippi River Commission for revision and publication. The amount appropriated is not sufficient to pay a special clerk for the work in this office, and as it has to be revised by the secretary of the Commission, I think it would be more satisfactory and economical to transfer the whole business to the Commission; and it would seem to come under the special province of that body in accordance with sections 3 and 4 of the act approved June 28, 1879."

A special boat is now employed by the Commission for the purpose of inspecting their own gauges, and as it has to pass by Major Willard's gauges, very little extra expense would be attached to their inspection and repair. I have no doubt that such a consolidation would materially reduce the cost of inspection.

I would also recommend that some arrangement be made with the Weather Bureau so that only one gauge at any given point will be read by Government observers. As it is now, at many places reports from different gauges are turned in by the Engineer Department and the Weather Bureau observers. These conflicting reports, when published in the daily press, give rise to great confusion, and sometimes, as during the last flood, cause needless alarm.

The self-registering gauges at Biloxi and Fort Jackson have been read throughout the year, but the record of the latter is very poor and it will soon be abandoned. The Biloxi record has been carefully kept and will doubtless eventually prove of great value in determining the mean gulf level.

The high-water gauges (182 in number) established every 5 miles between Cairo and Fort Jackson have been carefully read during the last flood, and it is believed that the extreme high-water plane has been better determined than ever heretofore. The gauges used are self-recording, and when not read by an observer little difficulty was experienced in locating the extreme readings from the water stains. A description and sketch of these gauges, and tables giving the elevations and the extreme readings, will be found in the report of J. A. Ockerson, principal assistant engineer, accompanying.

Discharge observations.—The gauge-inspection party on the steamer *Search* has also been charged with the obtaining of the high and low water discharges required by the Commission. The velocity measurements have been made with the Haskell current meter and with double floats. The result of these discharge observations will be found in Assistant Ockerson's report, appended.

The continuance of the extreme high stage throughout the entire lower river for so long a period is something remarkable.

Plant and outfit.—The steamer *Patrol*, survey boat *Illinois*, and fuel barge were used in the field the last season for the survey of the Mississippi River, spending the winter at Lansing, Iowa. These boats are now in the field with the regular survey party.

The steamer *Search* has been kept constantly in commission, engaged in making gauge inspections, discharge observations, and surveys in connection with dredging operations.

No extraordinary repairs to plant, under the allotment for surveys, gauges, and observations, have been found necessary during the past year.

Office work.—The usual office work in connection with surveys, gauges, and observations has been carried on during the past year. The detailed charts of the Mississippi River, 1:20,000, from the Head of the Passes to Davenport, Iowa, and the inch-mile sheets from the mouth of the Mississippi River to near Keithsburg, Iowa, have now all been published. The upper alluvial valley map has been published in two sheets, from Cairo, Ill., to above Burlington, Iowa. The other two sheets of this map have not yet been completed. A district map of the Lower Mississippi, in convenient form for reference and corrected according to the last information, has just been published.

Additional details of work relating to surveys, gauges, and observations will be found in accompanying report of Assistant J. A. Ockerson, to which attention is invited.

DREDGES AND DREDGING.

At the date of my last annual report only one dredge, the *Alpha*, had as yet been put in charge of the secretary. The contract for the *Gamma* had been let to John S. George and Howard P. Eells, receivers of Bucyrus Steam Shovel and Dredge Company, at South Milwaukee, Wis.

In May, 1896, the following plant for dredging operations was transferred from the First and Second districts:

1 quarter boat, *No. 13.*
1 tow boat, *Minnetonka.*
1 pile driver, *No. 21.*
1 fuel flat.
2 barges.

And the following from the Third district:

1 tow boat, *Vidalia.*
1 pile driver.
1 barge.

On June 30 1896, the dredge *Beta* was also transferred to the secretary from First and Second districts.

Field work.—Extensive repairs were made to the *Alpha* and *Beta* and plant during the summer, and dredging operations were begun September 1, 1896, and closed about the middle of November, 1896. Dredging was done at the following bars:

By *Alpha:*

Cherokee Crossing (89 R.), September 5–28, 1896.
Upper Point Pleasant (79 R.), September 29–October 19, 1896.
Compromise Bar (77 L.), October 24–November 15, 1896.

By Beta:

Island No. 40 (211 L.), August 31–September 24, 1896.
Island No. 34 (179 R.), September 25–30, 1896.
Osceola (164.5 R.), September 30–October 9, 1896.
Hathaways, Lower Crossing (102 L.), October 9–15, 1896.
Cherokee Crossing (89 R.), October 15–24, 1896.
Cherokee Crossing, November 3–13, 1896.
Lower Point Pleasant (79.5 R.), October 25–November 3, 1896.

The results of the dredging were generally satisfactory, an increased depth of from 1 to 4 feet at the lowest stage being obtained. A detailed report of the operations during the low-water season, made by me April 13 last to the President of the Mississippi River Commission, is appended hereto and attention is invited to the same. Attention is also invited to an appended report of Assistant Engineer C. W. Sturtevant on the subject of location of dredged channels.

At the close of the season the entire plant was put in winter quarters at East Cairo, Ky., only a small force being retained through the winter.

Further details relative to the care and repair of dredging plant will be found in report of Assistant Ockerson, appended, together with a table giving the cost of said repairs to May 1, 1897.

New dredges.—During the past year four new hydraulic dredges have been under construction for the Mississippi River Commission, of which two, the *Gamma* and *Delta*, are nearly ready for the tests prescribed by contract.

The construction of the *Gamma* was awarded to John S. George and Howard P. Eells, receivers Bucyrus Steam Shovel and Dredge Company, South Milwaukee, Wis., for the sum of $85,530.60. This contract was approved by the Chief of Engineers July 25, 1896.

The construction of the *Delta* was awarded after the passage of the act of June 3, 1896, to the New York Dredging Company, of New York, N. Y., for $124,940, the contract being approved by the Chief of Engineers September 19, 1896.

The general specifications for both these dredges will be found in the proposals printed in the report of the Mississippi River Commission for 1896, pp. 3467–3472. (Appendix W W, Annual Report of the Chief of Engineers for 1896.) The contract time for the completion of the dredge *Gamma* has been extended sixty days and that for the *Delta* thirty days on account of delays due to the extraordinary high water last spring.

After the passage of the act of June 3, 1896, the Mississippi River Commission directed the committee on dredges to prepare detailed plans for two new hydraulic dredges. Proposals for these dredges, the *Epsilon* and *Zeta*, were opened November 11, 1896, and the contract was awarded to the lowest bidders, The Springfield Boiler and Manufacturing Company, of Springfield, Ill. The contract price for the *Epsilon* is $102,000 and that for the *Zeta* $106,000. Contract for these two dredges was approved by the Chief of Engineers on December 31, 1896, and they are required to be delivered for test on or before October 6, 1897.

When these four dredges are completed the Commission will possess a fleet of six dredges. The adopted plans contemplate the construction of seven, and possible future construction of two additional dredges. The *Gamma* and *Epsilon* are provided with jet agitators and the *Delta* and *Zeta* with cutter agitators.

The construction of the hull of the *Gamma* was begun at Jeffersonville, Ind., on July 25, and it was launched on November 9. Immediately after launching, with the hull sections of the suction and discharge pipe aboard, the hull showed a draft of 18 inches forward and 12 inches aft. The boiler construction was begun August 11 and completed October 1. The erection of boilers, chimneys, etc., was practically completed by December 20, 1896. The cabin was completed by January 16. Construction of the machinery was begun as soon as the contract was signed and all shop work was completed by the end of January. The erection of the machinery was begun October 13, 1896, and was practically completed by the end of February, 1897. The dredge arrived at Cairo, Ill., on April 28, and has just been delivered to the Government at East Cairo, Ky., for inspection prior to test. The draft of the dredge in complete working order will probably not exceed 4 feet. A full description of this dredge and additional details relative to the history of its construction will be found in the appended report of Assistant J. A. Ockerson, to which attention is invited.

The hull of the *Delta* was constructed at Clifton Terrace, a short distance above Alton, Ill., on the Upper Mississippi River. The hull was launched on February 20, 1897. By the end of May the cabin had practically been completed. The machinery and boilers were constructed mainly in the vicinity of New York City and Philadelphia and completed about the end of January, 1897. The erection of machinery was begun on February 3, and is now about complete. The dredge was towed to St. Louis on May 17. Steam was raised on May 25. The floating pipe line has not yet been delivered at St. Louis. The draft of the boat in complete working order will be somewhat less than the contract requirement of 4¼ feet. Additional details of the history of the construction of this dredge and a full description of the various parts of the machinery will be found in the report of Assistant Ockerson, appended, to which attention is invited.

The hulls of the dredges *Epsilon* and *Zeta* are being erected by The Springfield Boiler and Manufacturing Company at Grafton, Ill. The work has not progressed very far, only the framing and bottom plating having as yet been erected. Progress is being made on the manufacture of the pumps and machinery. The contractors hope to be able to launch the hull by July 15, but this does not seem probable with the present rate of progress.

The specifications for the construction of these dredges will be found appended, Appendix B.

COMMERCIAL STATISTICS.

Commercial statistics relating to the Lower Mississippi River can not be obtained without employing special agents for their collection. The past year was unusually favorable for transportation interests, and it is known that the traffic was larger, particularly during the low-water season, than at any time previously in the last five years.

The following papers accompany this report:

Money statement.

Abstract of all proposals, in the order of date of opening bids.

List of contracts in force, with names of contractors, dates of approval, of beginning of work, and expiration.

Statement of charts issued and sold.

List of civilian engineers.

Approximate value of plant.

Appendix 7 A, laws affecting the Mississippi River Commission, March 4, 1895, to June 30, 1897.

Appendix 7 B, specifications for the construction of hydraulic dredges *Epsilon* and *Zeta*.

Appendix 7 C, report of Capt. H. E. Waterman, Corps of Engineers, secretary Mississippi River Commission, upon dredging operations on the Mississippi River between Cairo, Ill., and Memphis, Tenn., during low-water season of 1896.

Appendix 7 D, report of Assistant Engineer J. A. Ockerson on field work, office reduction and mapping, and on the construction, care, and repair of dredges.

Appendix 7 E, report of Assistant Engineer C. W. Sturtevant on location of dredge channels.

Respectfully submitted.

H. E. WATERMAN,
Captain, Corps of Engineers,
Secretary Mississippi River Commission.

Col. G. L. GILLESPIE,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

Money statement.

July 1, 1896, balance unexpended		$281,627.60
Amount appropriated by act of June 3, 1896	[a]$235,445.19	
Amount authorized by act of June 3, 1896	254,000.00	
Amount transferred by Capt. Graham D. Fitch, Corps of Engineers, in charge first and second districts	62,210.11	
Amount transferred from allotment for "Ashbrook Neck," third district	10,000.00	
		561,655.30
		843,282.90
June 30, 1897, amount expended during fiscal year		383,686.50
July 1, 1897, balance unexpended		459,596.40
July 1, 1897, outstanding liabilities	$68,395.76	
July 1, 1897, amount covered by uncompleted contracts	254,256.20	
		322,651.96
July 1, 1897, balance available		136,944.44
Amount that can be profitably expended in fiscal year ending June 30, 1899 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.		975,895.00

Abstract of proposals for hydraulic dredges, received in response to advertisement dated October 11, 1896, and opened by Capt. H. E. Waterman, Corps of Engineers, November 11, 1896.

No. of proposal.	Bidder.	For one dredge.		For two dredges.	
		For dredge with water-jet agitators.	For dredge with mechanical agitators.	For dredge with water-jet agitators.	For dredge with mechanical agitators.
1	Springfield Boiler and Manufacturing Co., Springfield, Ill	$105,507.97	$109,980.50	[b] $102,000.00	[b] $106,000.00
2	John S. George, H. P. Eells, receivers, Bucyrus Steam Shovel and Dredge Co., South Milwaukee, Wis	119,750.00	129,750.00	119,500.00	129,500.00
3	New York Dredging Co., New York, N. Y	200,000.00 [c] 105,000.00	....	[c] 100,000.00	....
4	.....do	....	200,000.00 [c] 105,000.00	....	[c] 100,000.00

---

[a] Does not include $1,964.81 allotted to secretary Mississippi River Commission out of amount appropriated by this act but expended by officer in charge of fourth district.

[b] Accepted.

[c] Specifications to be modified to their requirements.

Abstract of proposals for furnishing coal, received in response to advertisement dated May 3, 1897, and opened by Capt. H. E. Waterman, Corps of Engineers, June 2, 1897.

No. of proposal.	Name and address of bidder.	Lot I.—120.000 bushels coal.		Lot II.—80,000 bushels coal.		Remarks.
		Quantity.	Price per bushel.	Quantity.	Price per bushel.	
		Bushels.	*Cents.*	*Bushels.*	*Cents.*	
1	Cairo City Coal Co., Cairo, Ill.	60,000	5⅛	40,000	5⅛	From Mnddy Valley Mining and Manufacturing Company's mine, located at Hallidaysboro, Ill. In barges containing 3,000 to 10,000 bushels.
		60,000	6⅛	40,000	6⅛	From W. H. Brown Sons' (Pittsburg coal) mine, located at Monongahela.
		120,000	5⅛	80,000	5⅛	From Muddy Valley Mining and Manufacturing Company's mine, located at Hallidaysboro, Ill. In barges containing from 3,000 to 10,000 bushels.
		a 120,000	6⅛	*a* 80,000	6⅛	From W. H. Brown Sons' (Pittsburg coal) mine, located at Monongahela.
2	C. Jutte & Co., Pittsburg, Pa.	120,000	8	80,000	8	From Cincinnati mine, located at Courtney, on the Monongahela River, Pennsylvania.

a Accepted.

Abstract of proposals for furnishing the services of towboats, received in response to advertisement dated May 5, 1897, and opened by Capt. H. E. Waterman, Corps of Engineers, June 4, 1897.

No.	Name and address of bidder.	For period of 30 days or more.		For period less than 30 days.		Remarks.
		Name of steamer.	Rate per day.	Name of steamer.	Rate per day.	
1	Frederick Hartweg, Cincinnati, Ohio.	H. F. Frisbie	$49.00	H. F. Frisbie	$59.00	Accepted.
2	Huse & Loomis Ice and Transportation Co., St. Louis, Mo.	Jack Frost	40.00	Jack Frost	50.00	Do.
3	St. Louis and Mississippi Valley Transportation Co., St. Louis, Mo.	Future City	35.00	Future City	70.00	Do.
4	The McKinley Coal Co., Pittsburg, Pa.	Tom Rees No. 2	50.00	Tom Rees No. 2	100.00	
5	O'Neil & Co., Pittsburg, Pa.	Fred Wilson	78.00	Fred Wilson	140.00	
6	Lysle Coal Co., Pittsburg, Pa.	Josh Cook	79.00	Josh Cook	200.00	
7	Pacific Coal Co., Pittsburg, Pa.	Pacific No. 2	100.00			
8	Relief Towboat Co., New Cumberland, W. Va.	Relief	30.00	Relief	75.00	
9	Wm. B. Rodgers, Pittsburg, Pa.	Ironsides	80.00	Ironsides	100.00	
10	O. C. Douds, Woodlawn, Pa.	Pacific	20.00			
11	C. Jutte & Co., Pittsburg, Pa.	Onward Raymond Horner	35.00 80.00	Onward Raymond Horner	50.00 100.00	
12	Advance Coal Co., Pittsburg, Pa.	John Moren	37.50	John Moren	80.00	

Abstract of proposals for the construction of three stern-wheel steam tenders, recei response to advertisement dated May 25, 1897, and opened by Capt. H. E. Wate Corps of Engineers, June 24, 1897.

No.	Bidder.	For one steam tender.		For two steam tenders.		For three steam te	
		Material used in construction.	Price.	Material used in construction.	Price.	Material used in construction.	
1	Cincinnati Marine Rwy. Co., Cincinnati, Ohio.	Wood	$4,600	Wood	$9,200	Wood	$
2	Ed. J. Howard, Jeffersonville, Ind.	.....do	5,110	.....do	10,220	.....do	
		Steel frame and wood sheathing.	5,660	Steel frame and wood sheathing.	11,320	Steel frame and wood sheathing.	
*a*3	Iowa Iron Works, Dubuque, Iowa.	Wood	5,995	Wood	11,850	Wood	
		Steel frame and wood sheathing.	6,850	Steel frame and wood sheathing.	13,600	Steel frame and wood sheathing.	
		All steel except decks.	7,080	All steel except decks.	14,060	All steel except decks.	
4	Thos. P. Morse, St. Louis, Mo.	Wood	6,400	Wood	12,600	Wood	
5	Luther M. Emerson, St. Louis, Mo.	.....do	6,990	.....do	13,500	.....do	
b 6	Thomas M. Rees, Pittsburg, Pa.	.....do	8,300	.....do	16,400	.....do	
		Steel frame and wood sheathing.	11,200	Steel frame and wood sheathing.	22,200	Steel frame and wood sheathing.	
		All steel except decks.	11,700	All steel except decks.	23,200	All steel except decks.	

a Delivery to be made at Dubuque, Iowa. *b* Delivery to be made at Pittsburg, Pa.

List of contracts in force June 30, 1897, secretary's office, Mississippi River Commi

Contract for—	Contractor.	Date of contract.	Date of approval.	Date of beginning work.	Dat expir
Construction of one hydraulic dredge (Gamma).*a*	John S. George and Howard P. Eells, receivers, Bucyrus Steam Shovel and Dredge Co.	May 22, 1896	July 25, 1896	July 29, 1896	Mar. 2 Exte one n
Construction of one hydraulic dredge (Delta).*a*	New York Dredging Co.	June 25, 1896	Sept. 19, 1896	Sept. 25, 1896	May 2 Exte one n
Construction of two hydraulic dredges (Epsilon and Zeta).	The Springfield Boiler and Manufacturing Co.	Dec. 5, 1896	Dec. 31, 1896	Jan. 6, 1897	Oct.
200,000 bushels coal*b*	Frederick Hartweg	Apr. 24, 1896	May 20, 1896	June 1, 1896	Dec. 3

a Dredge now undergoing tests.
b Contract still in force until coal barges are returned by United States.

Statement of maps and charts issued and sold from June 1, 1896, to June 30, 189

Description.	Free.	Sold.	T
Upper alluvial valley map	2	2	
Lower alluvial valley map	40	192	
Inch to mile map	438	406	
Detail chart, 1:20,000	2,712	368	
Detail chart, 1:10,000 (harbor New Orleans)	72	40	
District map Lower Mississippi River	20	....	
Total	3,284	1,008	

Proceeds deposited with assistant treasurer of the United States at St. Louis, $135.39.

List of civilian engineers employed on works of the Mississippi River Commission in charge of Capt. H. E. Waterman, Corps of Engineers, secretary, from May 26, 1896, to June 30, 1897.

Name and residence.	Time employed.		Pay per month.	Where employed.	Work on which employed.
	Mos.	*Ds.*			
J. A. Ockerson, St. Louis, Mo.	13	5	$250	In field and secretary's office.	In charge of surveys, gauges, and observations.
Thos. Middleton, St. Louis, Mo.	13	0	200	.....do	In charge of dredge construction.
A. T. Morrow, Rockford, Ill.	13	5	175	.....do	Surveys and reduction of field work.
Kivas Tully, St. Louis, Mo.	13	5	175	Secretary's office	In charge of computing division.
C. W. Clark, Webster Groves, Mo.	13	5	175	.....do	Drawing maps, surveys, gauges, and observations.
W. G. Comber, Benton, Mo	13	5	150	In field and secretary's office.	Surveys and reduction of field work.
Geo. H. French, Benton, Mo.	4	5	135	.....do	Do.
C. W. Sturtevant, Appleton, City, Mo.	13	5	150	In field	Dredges and dredging.
Peter Mogensen, Champaign, Ill.	6	0	150	.....do	Do.
E. H. Twining, New York, N. Y.	13	5	175	President's office	Mississippi River Commission.

Approximate value of plant belonging to the United States used on works under the Mississippi River Commission, in charge of Capt. H. E. Waterman, Corps of Engineers, secretary.

Class of property.	No.	Present approximate value.
Dredge Alpha and outfit	1	$44,770.10
Dredge Beta and outfit	1	198,817.51
Dredge Gamma and outfit	1	86,935.33
Dredge Delta and outfit	1	125,742.69
Steamboat Mississippi and outfit	1	51,433.87
Steamboat Minnetonka and outfit	1	12,442.04
Steamboat Patrol and outfit	1	12,686.21
Steamboat Search and outfit	1	8,177.56
Steamboat Vidalia and outfit	1	2,432.66
Barges	15	15,000.00
Pile sinkers	3	7,500.00
Survey boat Illinois and outfit	1	1,800.00
Quarter boat No. 13 and outfit	1	1,800.00
Flatboats	3	900.00
Rowboats	31	600.03
Fuel barge	1	360.00
Surveying instruments		4,773.51
Drawing instruments		380.00
Printing plant		587.91
Diving outfit		671.50
Photographic outfit		324.79
Office furniture		988.25
Books, etc		207.00
Total		580,330.96

APPENDIXES ACCOMPANYING THE REPORT OF CAPT. H. E. WATERMAN, CORPS OF ENGINEERS, SECRETARY MISSISSIPPI RIVER COMMISSION.

A. Laws affecting the Mississippi River Commission, March 4, 1895, to June 30, 1897.

B. Specifications for the construction of hydraulic dredges Epsilon and Zeta.

C. Report of Capt. H. E. Waterman, Corps of Engineers, secretary Mississippi River Commission, upon dredging operations on the Mississippi River, between Cairo, Ill., and Memphis, Tenn., during the low-water season of 1896.

D. Report of Assistant Engineer J. A. Ockerson, on field work, office reduction, and mapping, and on the construction, care, and repair of dredges.

E. Report of Assistant Engineer C. W. Sturtevant on location of dredge channels.

LIST OF PLATES ACCOMPANYING THE REPORT OF CAPT. H. E. WATERMAN, CORPS OF ENGINEERS, U. S. A., SECRETARY MISSISSIPPI RIVER COMMISSION.

PLATE 1.—Point Pleasant and vicinity. Before dredging.
PLATE 2.—Compromise Bar (77). Before, during, and after dredging.
PLATE 3.—Upper Point Pleasant Bar (79). Before and after dredging.
PLATE 4.—Lower Point Pleasant Bar (79.5). Before and after dredging.
PLATE 5.—Cherokee Crossing (89). Before and after dredging.
PLATE 6.—Hathaways Lower Crossing (102). Before and after dredging
PLATE 7.—Osceola Bar (164). Before and after dredging.
PLATE 8.—Island No. 34 (179). Before and after dredging.
PLATE 9.—Island No. 40 (211). Before and after dredging.
PLATE 10.—Hydrographs of New Madrid, Fulton, and Memphis gauges. August to December, 1896.
PLATE 11.—Hydrographs Mississippi River, Cairo to Fort Jackson. 1897.
PLATES 12, 13, 14, 15, 16, 17, 18, 19,* 20,* 21,* 22,* 23, 24, 25, 26, 27, 28, 29, 30, 31.—Comparison of cross-section elements derived from surveys of 1882–83 and 1895–96, from Vicksburg, Miss., to Donaldsonville, La.

APPENDIX 7 A.

LAWS AFFECTING THE MISSISSIPPI RIVER COMMISSION, MARCH 4, 1895, TO JUNE 30, 1897.

[Copies of all previous laws will be found in the Annual Reports of the Mississippi River Commissio for 1889 and 1895.]

AN ACT Making appropriations for the construction, repair, and preservation of certain publi works on rivers and harbors, and for other purposes.

* * * * * * *

Improving Mississippi River from Head of Passes to the mouth of the Ohio River, including salaries, clerical, office, traveling, and miscellaneous expenses of the Mississippi River Commission: Continuing improvement, six hundred and twenty-five thousand dollars, which sum shall be expended under the direction of the Secretar of War, in accordance with the plans, specifications, and recommendations of th Mississippi River Commission, as approved by the Chief of Engineers, for the general improvement of the river, for the building and repairing of levees, and for surveys, including the continuation of the survey between Head of Passes and the hea waters of the river, such improvement, surveys, building and repairs of levees to b made and carried on in such manner as in their opinion shall best improve navigation and promote the interests of commerce at all stages of the river: *Provided,* That on and after the passage of this Act additional contracts may be entered int by the Secretary of War for such materials and work as may be necessary to carr on continuously the plans of the Mississippi River Commission as aforesaid, or sai materials may be purchased and work done otherwise than by contract, to be paid for as appropriations may from time to time be made by law, not exceeding in the aggregate eight million three hundred and seventy-five thousand dollars, exclusiv of the amount herein appropriated: *Provided further,* That for the fiscal year ending June thirtieth, eighteen hundred and ninety-seven, said contracts, and material purchased, and work done otherwise than by contract shall not exceed the sum o six hundred and twenty-five thousand dollars, and thereafter shall not exceed the sum of two million five hundred and eighty-three thousand three hundred and thirty-three dollars annually for the three years beginning July first, eighteen hundred and ninety-seven: *Provided further,* That the money hereby appropriated and authorized to be expended in pursuance of said contracts, or so much thereof a may be necessary, shall be expended in the construction of suitable dredge boats and other devices and appliances, and in the maintenance and operation of the same, with the view of ultimately obtaining and maintaining a navigable channel from Cairo down, not less than two hundred and fifty feet in width and nine feet in depth at all periods of the year except when navigation is closed by ice: *Provide further,* That of the sum hereby appropriated and authorized to be expended, the sum of sixty-four thousand dollars shall be expended in the rectification of the banks at Greenville, Mississippi, and sixty-four thousand dollars in the rectification of the banks at Helena, Arkansas, according to late plans submitted by Captain Graham D. Fitch, Corps of Engineers, and sixteen thousand dollars in the rectification of the banks at New Madrid, Missouri.

For work in accordance with the plans and specifications of the Mississippi Rive Commission:

---

* Not printed.

At the harbor of New Orleans, Louisiana: Continuing improvement, one hundred and ten thousand dollars;

At the harbor of Natchez and Vidalia, Mississippi and Louisiana, sixty-four thousand dollars;

For rectification of Red and Atchafalaya rivers, Louisiana: Continuing improvement, forty thousand dollars;

At the harbor of Memphis, Tennessee, seventy thousand dollars; of which thirty-five thousand dollars shall be expended in dredging and improving Wolf River from its mouth to the county bridge on Second street, not exceeding two and a half miles up said stream.

* * * * * * *

SEC. 2. That the Secretary of War is directed to cause to be prepared a compilation of all general laws that have been enacted from time to time by Congress for the maintenance, protection, and preservation of the navigable waters of the United States which are now in force, and to submit the same to Congress at its session in December next, together with such recommendation as to revision, emendation, or enlargement of the said laws as, in his judgment, will be advantageous to the public interest.

* * * * * * *

SEC. 5. That under the authority to make contracts for materials and work, under the provisions of this Act, in addition to the sums appropriated herein, the Secretary of War shall not obligate the Government to pay, in any one fiscal year, beginning July first, eighteen hundred and ninety-seven, more than four hundred thousand dollars upon the said contracts for any one of the works herein placed under the contract system, except as herein otherwise specifically authorized to do; *Provided* any part of the annual allotment herein provided for, not earned and paid for material furnished or work done in one fiscal year, may be paid for material furnished and work done under the contracts in any subsequent fiscal year: *Provided further*, That nothing herein contained shall be so construed as to prevent the Secretary of War from making contracts for the whole or any part of the works placed under the contract system in such manner as may be deemed best, payments, however, to be made as stated in this section.

SEC. 6. The Secretary of War is hereby authorized and directed to cause to be made and transmitted to the first session of the Fifty-fifth Congress a compilation giving a complete list of all the preliminary examinations that have heretofore been made, date of report, with a statement as to each, whether favorable or unfavorable for survey; also a complete list of all surveys that have heretofore been made, with a statement as to each, whether favorable for adoption or unfavorable, and date of report, amount recommended for completion and amount recommended for each to be expended during the fiscal year beginning July first, eighteen hundred and ninety-eight, by both the Chief of Engineers and the engineer in charge; also a complete list of all projects now under construction or maintenance, together with the year when adopted, and if modified, when, the total amount expended on each project and estimate of amount required to complete the same, and amount recommended by the Chief of Engineers and by the Engineer in charge to be expended during the fiscal year beginning July first, eighteen hundred and ninety-eight, the amount appropriated for each project by this Act, making reference to the report of the Chief of Engineers where report of each project is given, together with a statement containing the amount of the unexpended balance to the credit of each project July first, eighteen hundred and ninety-seven, whether under construction, work suspended, or appropriation made and work not commenced; also the total amounts appropriated heretofore for the improvement and maintenance of the rivers and the total amounts heretofore appropriated for the improvement and maintenance of harbors in each river and harbor act; also the total amount of appropriation by States for the improvement of rivers and harbors.

* * * * * * *

THOMAS B REED
Speaker of the House of Representatives.
A E STEVENSON
Vice-President of the United States and President of the Senate.

IN THE HOUSE OF REPRESENTATIVES, *June 2, 1896*

The President of the United States having returned to the House of Representatives in which it originated the bill (H. R. 7977) "An Act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," with his objections thereto the House proceeded in pursuance of the Constitution to reconsider the same; and

Resolved, That the said bill pass, two-thirds of the House of Representatives agreeing to pass the same.

Attest: A. MCDOWELL *Clerk*.

IN THE SENATE OF THE UNITED STATES, *June 3, 1896.*

The Senate having proceeded, in pursuance of the Constitution, to reconsider the bill entitled "An Act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," returned to the House of Representatives by the President of the United States, with his objections, and sent by the House of Representatives to the Senate, with the message of the President returning the bill:

Resolved, That the bill do pass, two-thirds of the Senate agreeing to pass the same.

Attest:

WM. R. COX *Secretary.*

[PUBLIC RESOLUTION—NO. 6.]

JOINT RESOLUTION Making appropriation for the improvement of the Mississippi River from the Head of the Passes to the mouth of the Ohio River, and to supply deficiencies in appropriations for the fiscal year ending June thirtieth, eighteen hundred and ninety-seven.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the sum of two hundred and fifty thousand dollars be, and is hereby, appropriated, and immediately made available, for the improvement of the Mississippi River from the Head of the Passes to the mouth of the Ohio River, and expended according to the provisions of the Act "Making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," which became a law on June third, eighteen hundred and ninety-six.

SEC. 2. That the sum herein appropriated be deducted from the sum of two million five hundred and eighty-three thousand three hundred and thirty-three dollars authorized to be appropriated and expended for the year ending June thirtieth, eighteen hundred and ninety-eight, by the provisions of said act of June third, eighteen hundred and ninety-six.

* * * * * * *

Approved, March 31, 1897.

[PUBLIC—NO. 2.]

AN ACT Making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and ninety-eight, and for other purposes.

* * * * * * *

UNDER THE WAR DEPARTMENT.

* * * * * * *

ENGINEER DEPARTMENT.

* * * * * * *

Improving Mississippi River: For continuing improvement of Mississippi River from Head of the Passes to the mouth of the Ohio River, including salaries, clerical, office, traveling, and miscellaneous expenses of the Mississippi River Commission, two million nine hundred and thirty-three thousand three hundred and thirty-three dollars; which sum, in the discretion of the Secretary of War, may be immediately available for expenditure under contract or otherwise. And of the sum hereby appropriated, six hundred thousand dollars shall be deducted from the sum of two million five hundred and thirty-three thousand three hundred and thirty-three dollars authorized to be appropriated and expended for the fiscal year ending June thirtieth, eighteen hundred and ninety-nine, by the "Act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," which became a law on June third, eighteen hundred and ninety-six.

* * * * * * *

And hereafter the Secretary of War shall annually submit estimates in detail for river and harbor improvements required for the ensuing fiscal year to the Secretary of the Treasury to be included in, and carried into the sum total of, the Book of Estimates.

* * * * * * *

Approved, June 4, 1897.

APPENDIX 7 B.

IMPROVING MISSISSIPPI RIVER.—ADVERTISEMENT, INSTRUCTIONS, SPECIFICATIONS, PROPOSAL, ETC., FOR HYDRAULIC DREDGES FOR MISSISSIPPI RIVER COMMISSION.

ADVERTISEMENT.

Proposals for hydraulic dredges.

MISSISSIPPI RIVER COMMISSION,
2732 Pine Street, St. Louis, Mo., October 12, 1896.

Sealed proposals for two hydraulic dredges will be received here until 12 o'clock noon, standard time, November 11, 1896, and then publicly opened. Information furnished on application.

H. E. WATERMAN,
Capt. Engrs., Secty.

SPECIFICATIONS.

General instructions for bidders.

1. The attention of bidders is especially invited to the acts of Congress approved February 26, 1885, and February 23, 1887, as printed in vol. 23, page 332, and vol. 24, page 414, United States Statutes at Large, which prohibit the importation of foreigners and aliens, under contract or agreement, to perform labor in the United States or Territories or the District of Columbia.

2. Preference will be given to articles or materials of domestic production, conditions of quality and price being equal, including in the price of foreign articles the duty thereon.

3. Bidders or their authorized agents are expected to visit the localities where work is to be done and to make their own estimates of the facilities and difficulties attending the execution of the work, including the uncertainty of weather and all other contingencies.

4. No proposal will be considered unless accompanied by a guaranty in manner and form as directed in these instructions.

5. All bids and guaranties must be made in triplicate, upon printed forms to be obtained at this office.

6. The guaranty attached to each copy of the bid must be signed by two responsible guarantors, to be certified as good and sufficient guarantors by a judge or clerk of a United States court, United States district attorney, United States commissioner, or judge or clerk of a State court of record, with the seal of said court attached.

7. A firm as such will not be accepted as surety, nor a partner for a copartner or firm of which he is a member. Stockholders who are not officers of a corporation may be accepted as sureties for such corporation. Sureties must be citizens of the United States.

8. Each signature to guaranties and bonds shall have affixed to it an adhesive seal. All signatures to proposals, guaranties, contracts, and bonds should be written out in full, and each signature to guaranties, contracts, and bonds should be attested by at least one witness, and, when practicable, by a separate witness to each signature.

9. Each guarantor will justify in the sum of twenty-five (25) per centum of the total amount of the bid. The liability of the guarantors and bidder is determined by the act of March 3, 1883, 22 Statutes, 487, chap. 120, and is expressed in the guaranty attached to the bid.

10. A proposal by a person who affixes to his signature the word "president," "secretary," "agent," or other designation, without disclosing his principal, is the proposal of the individual. That by a corporation should be signed with the name of the corporation, followed by the signature of the president, secretary, or other person authorized to bind it in the matter, who should file evidence of his authority to do so. That by a firm should be signed with the firm name, either by a member thereof or by its agent, giving the names of all members of the firm.

11. The place of residence of every bidder, and post-office address, with county and State, must be given after his signature.

12. All prices must be written as well as expressed in figures.

13. One copy each of the advertisement, the instructions for bidders, and the specifications, all of which can be obtained at this office on application by mail or in person, must be securely attached to each copy of the proposal and be considered as comprising a part of it.

14. Proposals must be prepared without assistance from any person employed in or belonging to the military service of the United States or employed under this office.

15. No bidder will be informed, directly or indirectly, of the name of any perso intending to bid or not to bid, or to whom information in respect to proposals ma have been given.

16. Anyone signing the proposal as the agent of another or others must file wit it legal evidence of his authority to do so.

17. All blank spaces in the proposal and bond must be filled in, and no chang shall be made in the phraseology of the proposal or addition to the items mentione therein. Any conditions, limitations or provisos attached to proposals will be liabl to render them informal, and cause their rejection.

18. Alterations by erasure or interlineation must be explained or noted in the proposal over the signature of the bidder.

19. If a bidder wishes to withdraw his proposal he may do so before the time fixe for the opening, without prejudice to himself, by communicating his purpose in writing to the officer who holds it, and, when reached, it shall be handed to him or hi authorized agent, unread.

20. Reasonable grounds for supposing that any bidder is interested in more tha one bid for the same item will cause the rejection of all bids in which he is interested

21. No bids received after the time set for opening of proposals will be considered

22. The proposals and guaranties must be placed in a sealed envelope marke "Proposals for dredges" and inclosed in another sealed envelope addressed to "Capt H. E. Waterman, Corps of Engineers, U. S. A., secretary Mississippi River Commission No. 2732 Pine street, St. Louis, Mo." The outer envelope must be so indorsed as t indicate before being opened the particular work for which the bid is made.

23. The United States reserves the right to reject any and all bids, and to waiv any informality in the bids received; also to disregard the bid of any failing bidde or contractor known as such to the Engineer Department.

24. The bidder to whom award is made will be required to enter into written contract with the United States, with good and approved security, in an amount of no less than twenty-five (25) per centum of the total amount of the contract, within te (10) days after being notified of the acceptance of his proposal.

25. The contract which the bidder and guarantors promise to enter into shall be, in its general provisions, in the form adopted and in use by the Engineer Department of the Army, blank forms of which can be inspected at this office, and will be furnished, if desired, to parties proposing to put in bids. Parties making bids are to be understood as accepting the terms and conditions contained in such form of contract.

26. The sureties are to make and subscribe affidavits of justification on the bac of the bond to the contract, and they must jointly justify in double the amount o the penalty.

27. Bidders are invited to be present at the opening of the bids.

General conditions.

28. A copy of this advertisement, specifications, and instructions will be attached to the contract and form a part of it.

29. The contractor should, within ten days from the award of the contract, furnish the office with the post-office address to which communications should be sent.

30. Transfers of contracts, or of interests in contracts, are prohibited by law.

31. The contractor will not be allowed to take advantage of any error or omission in these specifications, as full instructions will always be given should such error or omission be discovered.

32. The decision of the engineer officer in charge as to quality and quantity shall be final.

33. It is understood and agreed that the quantities given are approximate only, and it must be understood that no claim shall be made against the United States on account of any excess or deficiency, absolute or relative, in the same. Bidders are expected to examine the drawings, and are invited to make the estimate of quantities for themselves.

34. Payments will be made for either dredge only on its acceptance after undergoing the prescribed tests. Payments will be contingent on such appropriations as may be made from time to time by law and on remittances thereunder from the U. S. Treasury.

35. Should the time for the completion of the contract be extended, all expenses of any nature whatever that may be incurred by the United States by reason of such extension, the same to be determined by the engineer officer in charge, shall be deducted from payments due or to become due to the contractor: *Provided, however,* That if the party of the first part shall, in the exercise of his discretion, because of freshets, ice, or other force or violence of the elements, allow the contractor additional time in writing as provided for in the form of contract, there shall be no deduction for such expenses for the additional time so allowed; *Provided, further,* that nothing in these specifications shall affect the power of the party of the first

part to annul the contract as provided for in the form of contract adopted and in use by the Engineer Department of the Army.

36. The contract to be entered into and of which these specifications will form a part is for furnishing and delivering to the United States, hydraulic steel-hull dredges capable of dredging one thousand (1,000) cubic yards of sand per hour from a depth of fifteen (15) feet and of delivering the same through one thousand (1,000) feet of floating pipe with a deflection of five hundred (500) feet, together with all the appurtenances and appliances necessary for the same, complete in each and every part, and all built in a good, substantial manner, of the best material and workmanship.

37. Proposals will be received for two dredges, which differ from each other slightly, as is hereinafter described. Bidders must state distinctly in their proposals which of the two they propose to furnish for the price named by them.

No. 1.—*Specification of hydraulic dredge with water-jet agitators.*

38. This specification shall be known as specification No. 1, October 12, 1896, and shall relate to the construction of a hydraulic dredge having "water-jet agitators" to stir up the sand at the mouth of the suction pipes. The dredge is designed to have a capacity of one thousand (1,000) cubic yards of sand per hour, dredged from a maximum depth of fifteen (15) feet and delivered at a distance of one thousand (1,000) feet by a floating pipe line. The hull is of such size as will carry the machinery contemplated on a draft of 48 inches, but, should the intending bidder consider that the dimensions adopted are insufficient to carry the machinery he proposes to furnish on that draft, he shall be at liberty to increase the length and width of dredge to suit his requirements, in order that the said draft of 48 inches shall not be exceeded. The dredge will be operated by a straight upstream movement, and is designed to make a channel of not less than twenty (20) feet in width at the bottom, at each cut.

39. *Drawings.*—Only general drawings of the dredge and of such parts as it is desired to make standard will be issued by the United States. All other working drawings shall be made by the contractor as part of the contract and shall be submitted to the U. S. engineer officer in charge for examination before the work is proceeded with. Such examination, however, shall not relieve the contractor from any of the requirements or obligations enjoined upon him by the terms of the contract.

40. *Contractor's drawings, etc.*—The contractor shall furnish a complete set of tracings of all working drawings used in the construction of the dredge, which shall be placed in the hands of the United States engineer officer in charge before final payment is made.

41. *Weights of machinery, etc.*—Each copy of the proposal must have attached to it a general specification of the machinery proposed to be furnished, and also a list of the weights of the same.

42. *Hull.*—The hull is to be built of steel throughout, as shown in drawings Nos. 5 and 6, and in accordance with the rules of the American Shipmasters' Association in so far as such rules are applicable. Hull to be 152 feet long, 40 feet beam, and 7 feet 6 inches deep, molded dimensions. The draft of dredge, when equipped with properly designed machinery and supplied with coal, water, and everything necessary for actual operation, shall not exceed 48 inches. The opening or well in bow, in which the suction pipes are placed, to be 22 feet wide at forward end, 18 feet wide at after end, by 32 feet long; and the two projecting ends thus formed to be strongly tied together by a box girder 36 inches wide and 36 inches deep. The junction of this girder with sides of well to be reinforced with angles and cover plates. Two angles to be riveted on the front of this girder, perforated with holes to receive the screen bars, which are to be made of 3-inch double extra heavy pipe, to be spaced 4 inches apart in the clear and to hang 9 inches below the surface of the water. The hull to be open in the parts occupied by the pumping machinery and boilers and to be decked over the remaining parts with steel plate. The afterdeck to project 39 inches beyond the stern of dredge, for the full width of hull, and the guard thus formed to be strongly connected to hull by ten gussets of $\frac{5}{16}$-inch plate and to have a fender plate 12 inches wide and $\frac{3}{8}$-inch thick riveted on outside edge with a 3-inch steel angle. A fender strake of white oak to be neatly fitted under sheer angles and secured to hull by $\frac{3}{4}$-inch bolts, at about 15 inches pitch, staggered. The side fender strakes to be 6 inches wide and 10 inches deep, and the stern fender strake to be 8 inches wide and 12 inches deep, all to be laid on a thickness of hair felt, the hull having previously received two coats of strictly pure red lead and oil. The aftercorners of fender strakes to be protected with iron straps 8 inches wide and $\frac{3}{4}$-inch thick, secured by $\frac{3}{4}$-inch countersunk bolts. The floor beams to be of 12-inch steel channels, 25 lbs., except at sides of well, where they will be 12-inch, 20 lbs. Frames to be of 3-inch x 4-inch angles 11 lbs., connected to floor and deck beams by gussets, and spaced 24 inches apart in the compartment containing main pump and engines, and 30 inches apart throughout remainder of dredge. Ten keelsons of 15-inch steel I beams, to run all fore and aft; the two outboard keelsons to

be 55 lbs., and the eight intermediate keelsons 45 lbs. Keelsons to be in as long pieces as practicable, connected by double butt straps of ⅜-inch plate flanged to fi accurately between flanges of I beams and treble riveted with ¾-inch diameter rivets The butts of consecutive keelsons to be about six floor-beam spaces apart and eacl keelson to be attached to each floor beam by two ¾-inch diameter rivets.

43. Outside plating of hull to be not less than six frame spaces in length. Th butts of adjoining strakes to have a shift of not less than two frame spaces an those of alternate strakes a shift of not less than one frame space. The center strak of bottom plating to be ⅜-inch thick, and all other strakes to be 5/16-inch thick. Th upper strake of side plating to be ⅜-inch thick and the lower strake to be 5/16-incl thick. The bottom plating to be continued up to deck line at stern to form en plating; and also at after end of well, as far up as the pipe frame strake, which wil be a single plate ⅜-inch thick. The bow end plates and rake to be ⅜-inch thick an all side plates in well to be 5/16-inch thick.

44. The butts of all outside plating to be planed or chipped fair and fitted close metal to metal, and all shearing to be done from the faying surface of plates. Th butts of bottom plates to be treble riveted and to have single butt straps 10⅝ inche wide and ⅛-inch thicker than the plates which they connect. The butts of sid plates to be double riveted and to have single butt straps 7½ inches wide and ⅛-incl thicker than the plates which they connect. All butt straps to be in one piece an to entirely cover the seams over which they are fitted. The fiber of double an treble riveted butt straps must be in the same direction as the plates to which the are secured. All longitudinal seams of outside plating to be single-riveted lap 2 inches wide. Solid liners in one length to be fitted at every frame, between frames and outside strakes of outside plating. Liners to be the width of the flange of th frame to which they are fitted, and to be carefully fitted so as to fill the entire spac between the edges of the inside strakes.

45. The deck plating to be ¼ inch thick except at sides of engine and boiler hatches where it must be 5/16 inch thick. Longitudinal seams to be single-riveted lap, an the transverse seams to be double-riveted butt with single straps on the under sid 7½ inches wide and 1/16 inch thicker than the plates which they connect.

46. The hull to be divided into eleven water-tight compartments by fore and af and athwartship bulkheads, as shown on drawing No. 5. Bulkheads to be ¼ incl thick, stiffened with 2½-inch angle bars, and to have single-riveted seams. The inter costals for floor beams and keelsons for water-tight bulkheads to be of pressed plate 5/16 inch thick. The bow plating, to which suction-pipe frame is attached, to be stif ened with tie plates to false bulkhead and all holes cut in bulkheads for suction, dis charge, or other pipes, to be efficiently compensated where necessary and mad thoroughly water-tight.

47. Coal bunkers of about 30 tons capacity to be provided with proper and con venient doors in stoke hold. The stoke hold and bunker to be floored with stee plate 3/16 inch thick, butt jointed on keelsons, and closely fitted to discharge pip which passes through center of dredge. A suitable well for spud anchor to be buil in forward part of hull, as shown on drawing No. 6. All foundation plates, stiffening plates, and angles necessary for pumps and machinery to be built in hull as required and all wood or iron floors, platforms, stairs, or ladders, required for the proper fit ting out and completion of the dredge to be supplied and fixed in place.

48. The "A" frame, from which suction pipes in well are suspended, to be built o steel channels and I beams, as shown on drawing No. 9, and securely riveted to hull

49. The through-deck beams under machinery on forward deck to be of 6-inch bul angles, 12.3 lbs.; all other through-deck beams to be 5-inch bulb angles, 10 lbs. Decl beams at side of well to be 5-inch bulb angles, 10 lbs., and the short deck beams a sides of engine and boiler hatches to be 3-inch angle bars, 6 lbs. The deck to be wel supported by iron stanchions riveted to beams and keelsons, and extra stanchions t be put in under machinery.

50. Rivets to be of soft steel and ⅝-inch diameter throughout the hull, excep where otherwise specified or noted on drawings, or where the nature of the worl requires a different size. The rivets in seams or laps of outside plating to be space longitudinally not more than 2½ inches center to center, and rivets in seams or lap of all internal water-tight work to be spaced not more than 2¾ inches centers. Al double riveting, including butts, to be chain fashion, except where otherwise note on drawings, the distance from center to center between the rows to be 1⅝ inches No rivet to be nearer the seam, butt, or edge of a plate or angle bar than its diameter Spacing of rivets in beam knees to be from 2¾ inches to 3½ inches centers, but no beam knee to be secured to its frame with less than four rivets. Rivets for securing outside plating to floors and frames, stiffening angle bars to bulkheads, and all worl where angle bars do not require to be calked to be spaced not more than 5 inche centers. Angle-bar clips and splice pieces to have not less than four rivets in each flange. Rivet holes to be regularly spaced and punched from faying surfaces and t be opposite each other in adjoining surfaces. Heavy drifting not to be resorted to.

Holes not punched fair to be drilled or reamed fair and a size of rivet to fit the hole to be used. Countersinks to be not less in depth than three-fourths the thickness of plate or angle bar countersunk. Rivets to completely fill their respective holes, and the heads to be laid up in outside plating and all other water-tight work; the points of rivets when finished to completely fill the countersinks and be slightly convex or flush with their respective plates or angle bars.

51. The hull to have all necessary hatchways, with suitable deck rings or coamings, gratings, and covers; also convenient ash chutes in stoke hold, with doors for same. The hull to be further provided with all necessary bitts, fair-leads, and cleats, secured in a good and substantial manner, and also a davit at the stern to lift the coupling hose of pipe line. The water-tight compartments to be fitted with 3-inch bilge syphons; two in each of the five large compartments and one in each of the compartments at sides of well and engine and boiler rooms, sixteen in all. The discharge pipes for syphons to be attached to outside plating by flanges and bolts, and all valves to be placed so as to be easily accessible from deck. All other pipes, such as water-closet pipes, blow-off pipes, overflow and drain pipes, etc., discharging through sides of dredge must be attached to plating by flanges, either bolted or riveted.

52. *Deck houses.*—An upper deck to extend over the whole length of main deck, on which will be built the cabins, etc. The forward part of main deck, on which the operating machinery and platform are placed, to be open at front, but to be provided with shutters and removable panels for closing in when dredge is laid up. The central part, comprising the engine room and workshop, to be inclosed, and have extra large windows and removable panels large enough to pass the largest piece of machinery. The after part, or boiler room, to be inclosed in such manner as to give ample light and ventilation and yet be a sufficient protection in rough weather. A water-closet and wash room for crew to be placed on half-deck above boilers, fitted with bath, iron washbowls, and all necessary water and drain pipes.

53. *Cabin, etc.*—A cabin shall be built on upper deck sufficient to provide quarters for officers and a double crew, in accordance with drawing No. 2, and shall include all lockers and tables; all bath rooms and water-closets with suitable and approved fittings; a kitchen, with all requisite tables, sinks, and lockers, and all pipes and fittings necessary for the distribution and disposal of water and drainage. A water tank of galvanized iron of 600 gallons' capacity, with suitable covers, to be provided and placed on roof of cabin and fitted with pipe connections from fire pump and overflow. Two ice boxes and cold stores to be built in afterhold of dredge, of such size as may be required. Proper and convenient hatchways for ice and for access to boxes to be provided, with means for locking same. A gangway to run all around the upper deck, protected by substantial hand rail, and all stairs or ladders, all hatches and hand rails, hose racks and stands for fire pails, flag poles and other necessary fittings to be furnished. Bunks and beds are not to be included in the contract, as they will be of iron.

54. *Upper decks, etc.*—The outside or exposed parts of upper decks to be covered with 12 oz. linen duck laid on a coat of strictly pure thick white lead and oil in the best manner, and when dry to receive two more coats of strictly pure white lead and oil; and the decks and houses to be fitted with all requisite scuppers and drain pipes of substantial make and good workmanship.

55. *Painting.*—All iron surfaces must be cleaned, scales and all traces of oxidation removed before painting is begun. The hull to receive three coats of strictly pure lead and oil, both inside and out. The machinery to be painted with two coats of good oil paint of such color as may be selected, the last coat to be put on after all preliminary trials have been made, before dredge is handed over to the engineer officer in charge. The cabins and woodwork shall receive one coat of priming and two coats of strictly pure white lead and oil, and the name of the dredge and other lettering required shall be done as directed. And it must be understood that all machinery, hull, and boilers must be inspected before being painted, and for that purpose the contractor shall notify the inspectors when any part of the machinery is ready for painting.

56. *Main dredging pump.*—The main dredging pump to be of the centrifugal double-suction type and to be placed on center line of boat, as shown on drawing No. 1. This pump shall have a capacity of not less than one thousand (1,000) cubic yards of sand per hour while delivering its material through one thousand (1,000) feet of 32-inch diameter pipe. The pump runner to be of such diameter as will give required performance without forcing engine beyond its average rating. The shaft to be of hammered steel, of such size as will resist all tendency to spring, with journals of ample size to insure cool running in continuous service, and should be proportioned so as not to exceed a surface speed of 350 feet per minute. The casing of pump to be divided horizontally through axis of shaft to enable shaft and runner to be easily removed; and the parts of pump casing exposed to wear from the action of the sand must have an average thickness of at least 2 inches. The stuffing boxes at sides of

pump to be fitted with brass bushes of best quality and to have sand intercepti
chambers to which water-jet connections from fire pump will be made. The pu
to be provided with an air exhauster or primer of ample capacity and suitably c
nected, with all pipes and valves necessary for same. All pieces of pump casing
other parts of machinery that have to be frequently handled must be amply p
vided with eye bolts, lugs, and shackles suitable for lifting same.

57. *Main engines.*—The engines for driving pump to be horizontal compound, n
condensing, directly connected, and to develop at least six hundred (600) I. H.
when running at their average speed, but to be capable of developing at least
per cent more power without any signs of overstraining or heated bearings. T
must be of as simple design as possible, heavy and substantial in build, and h
extra large wearing surfaces, and be fitted up in the best possible manner and
accordance with best practice for high-velocity engines. All sight feed and ot
lubricators adapted to continuous service to be supplied and fitted in place,
indicator cocks and connections for taking diagrams. An engine floor or platfo
at suitable height for attending to engines, to be provided; and all valves and h
dles necessary for operating this part of the machinery to be placed in positi
most convenient to be handled from this platform.

58. *Gauges, etc.*—All necessary gauges and pressure indicators of a pattern t
approved by the engineer officer in charge shall be furnished and put in place
the contractor.

59. *Jet pump and engines.*—Jet pump for supplying water under pressure to
nozzles of suction heads to be of the centrifugal type and capable of supplyin
cubic feet of water per second, at a pressure of 15 lbs. per square inch. The en
to be compound noncondensing, directly connected, and to be of equally good de
and construction, and to be supplied with all the accessories that are specified
main engines. The suction for this pump to be taken from side of dredge near
bottom, and the mouth to be protected with a bar screen to prevent drift from p
ing through pump and into nozzles. A straightway valve of same diameter as
tion pipe to be placed as near the inlet as practicable and a steam connection provi
for clearing away drift from screen.

60. *Water jets and pipes.*—The nozzles for water jets to be ten in number and 3-i
diameter of bore. They must be made of phosphor-bronze and screwed into fac
pressure chamber on suction head, in positions shown on drawing No. 7. The w
to be supplied to pressure chamber by pipe carried on suction frame and conne
to hull by a radial joint, as shown in detail on drawing No. 8.

61. *Suction pipes.*—Two suction pipes, made of steel plate and rigidly tied toge
by suitable framing, to be suspended in well, and attached to hull by radial joi
as shown on drawing No. 8. This framing to be a riveted structure, efficiently br
to resist all strains, and made in such a manner that the jet pipe can be carrie
the middle and be readily removed at any time. Suction pipes to be 24⅜ in
inside diameter and 5/16 inch thick, and each pipe to be made in three rings, with
longitudinal seams single riveted lap and the circular seams single riveted butt,
outside straps 5¼ inches wide and ⅜ inch thick. A 4-inch Z-bar to be rivete
center line of upper and lower sides of each pipe, to which the diagonal and tr
verse bracing is to be attached by gusset plates. The flanges at ends of pipes t
steel castings and have provision made on them for attaching gusset plates of b
ing, and to have landing on pipes sufficient for double riveting. The suction h
to be made of steel plates ⅜ inch thick of the form and size shown on drawing N
The junction pieces, which change the shape from rectangular to circular, to be
castings, with flanges well bracketed, and to have at least 9 inches of landin
plates, with double row of rivets. Six screen bars made of steel plate ¼ inch t
to be placed in mouth of each suction head, and heads to be further stiffened by
tie plates 5/16 inch thick. Two 4-inch steel angle bars to run all along top side of he
to which the lugs for straining frame and sling chains are to be riveted. The p
sure chamber which is riveted on under side of heads is to be a steel casting, m
in halves and bolted together on center line, and fitted with the nozzles describe
paragraph 50. All rivets in suction heads and pipes to be flush on inside an
bolted joints to be faced. The straining frame, shown on drawing No. 9, to be m
to fit on suction heads and to work in pinning brackets, which last are to be
castings riveted on bow girder.

62. *Radial joints.*—Each radial joint for suction pipes to consist of three p
The "stuffing box" to be a steel casting with heavy flange to bolt to hull of dre
and lugs for carrying suction frame and from which the frame will radiate, an
be fitted with rubber packing ring, etc., as shown on drawing No. 8. The "r
pipe" which slides in above stuffing box to be cast iron 24¼ inches diameter in
and machine finished outside. The "flange piece," which is riveted to suction p
to be a steel casting and have heavy lugs fitting into those on stuffing box, all
nected by a finished steel pin 3 7/16 inches diameter. All parts of the radial jo
must be of ample strength to take all strains to which they may be subjected,

must be thoroughly well fitted, and great care must be exercised in fixing them truly in line on hull of dredge. The radial joint for pressure pipe of jet pump to be of similar general construction to the above, but to have ordinary packing gland, and to be without hinge lugs. All the parts to be cast iron and of ample strength, and the radial pipe to be machine finished. All radial joints to have sufficient range to admit of dredging in 15 feet depth of water and to raise jet nozzles above bow girder, and to be so arranged that when dredging in 6 feet of water the end of radial pipe shall offer no obstruction to the flow of water to pump.

63. *Suspension tackle.*—The lower end of suction pipes to be suspended from "A" frame at bow of dredge, by wire rope hoisting tackle consisting of 3 parts of ¾-inch diameter wire rope. The sheaves to be 30 inches diameter and to have pins of such size that the bearings shall not be loaded more than 1,000 lbs. per square inch. The connection to suction heads to be made by sling chains long enough to keep rope out of water, and all sheave frames, shackles, and other attachments to be forged and fitted in the best possible manner. Snatch blocks for bow ropes to be also suspended from "A" frame, and to be made in similar manner and with the same size sheaves as described for hoisting tackle.

64. *Hoisting winch.*—The winch for raising suction pipe frame to be placed near the center line of dredge on forward deck, and to have double engine and be of such power as will raise frame easily at the rate of 30 feet per minute and yet not powerful enough to break a ¾-inch "Hercules" steel rope when working with average boiler pressure. The drum to be 42 inches diameter and of sufficient length to take the requisite quantity of rope in one lay, all as shown on drawing No. 10. Winch to be fitted with brake sufficiently powerful to hold the frame in any position; and engine to have reversing motion, and be furnished with all necessary lubricators, valves, pipes, and drains.

65. *Bow-winches.*—Two bow-winches to be placed near sides of well on forward deck, as shown on drawings Nos. 1 and 10, for operating the forward or feed movement of dredge. These winches to have double engines geared in such a ratio that they will wind up at speeds varying from ¼ inch to 7 inches per second, with drums at least 42 inches diameter, and of sufficient length to hold 1,200 feet of ¾-inch diameter wire rope, in two lays, and must be fitted with clutches and brakes so that drums may be overhauled and lines paid out quickly. Engines to have reversing motion, and be furnished with all necessary lubricators, valves, pipes, and drains.

66. *Spud anchor and engine.*—The spud anchor to be of oak 22 inches square and 32 feet long, fitted with cast-iron shoe and cap, and arranged to work in a well provided for that purpose at bow of dredge. The spud to be fitted with hydraulic power for sinking, as shown on drawing No. 11, and to be connected to fire-pipe line by 3-inch diameter rubber hose. The winch for lifting spud to have double engine and to be of sufficient power to raise twice the weight of spud, easily, with a steam pressure of 100 lbs. per square inch. The drum to be 30 inches diameter, fitted with friction clutch and ratchet. The pinions of all the winches to be of steel, and all the engines to have phosphor-bronze bearings and be adjustable for wear in all the usual parts, and be fully provided with all operating handles, lubricators, valves, and pipe connections.

67. *Steam capstans.*—Four steam capstans for handling side lines, to be provided and placed as indicated on drawing No. 1. They must be of some make approved by the engineer officer in charge, with double engines having cylinders not less than 5 inches diameter and 7 inches stroke and fitted with all pipes and valves and levers, arranged in such a manner as to be conveniently operated from deck. The engines to be placed in hold of dredge.

68. *Operating levers, etc.*—A strong platform to be built on forward deck, abaft the winches, from which the dredge will be operated, and all the handles and levers necessary for this purpose to be arranged in the most convenient manner, and in such position that the operator can see the suction pipes and all the machinery on forward deck. The dredge must be equipped in the most complete manner, with all signals or other means of communication between its several parts, necessary for the efficient and handy operation of the dredge.

69. *Boilers.*—Steam to be supplied by six boilers of the Mississippi River steamboat type, each 48 inches in diameter and 28 feet long and containing five flues each 11 inches diameter. These boilers to be made of marine steel of 60,000 lbs. tensile strength, and in strict accordance with the requirements of the rules prescribed by the "Board of Supervising Inspectors" for a working pressure of 140 lbs. per square inch. The boilers to be arranged in two batteries, and each battery to have one steam drum 30 inches diameter and two mud drums 15 inches diameter, properly riveted to their places. All holes in shells to be drilled and all seams to be double riveted. All furnace fronts and grates, and all sheet-iron casings to be furnished, and boilers to be bricked in, in a thoroughly first-class manner. All the usual and necessary fittings, pipes, and valves to be supplied and arranged in most convenient positions for working same. Smoke stacks to be 42 inches diameter and about 70

feet high, and supplied with all necessary casings, umbrellas, and wire-rope g Before the dredge is submitted to the efficiency test, the boilers and all the connections shall undergo the usual hydrostatic test to a pressure of 210 lbs square inch, to the satisfaction of the engineer officer in charge or such agent shall appoint for the purpose.

70. *Feed pumps.*—Two feed pumps with outside packed plungers, which shoul be less than 4¼ inches diameter and 10 inches stroke, to be supplied, each capab delivering 60 gallons per minute at average working speed. These pumps mu of some make approved by the engineer officer in charge and have brass bush glands and stuffing boxes of water cylinders and be fitted with all necessary l cators, valves, and pipe connections.

71. *Heater.*—A feed-water heater of some make approved by the engineer offic charge, and of ample capacity to supply the boilers, to be placed in engine room fitted with all necessary connections.

72. *Pump well.*—The pump well to be 5 feet long, 2 feet 6 inches wide, and 4 f inches deep, made of steel plate 3/16 inch thick, with a band of 2-inch angl around the top edge; the flange of this angle bar to be perforated with 11/16-inch about 6 inches pitch. A removable screen of heavy wire about ¼-inch mesh to be in well. The supply pipe to be 6 inches diameter, and to have a single gate placed as near to inlet as practicable, and the mouth protected by a bar scree 1¼-inch steam connection to be provided, to clear away drift, etc., from screen. inch brass screw plug to be fitted to bottom from inside, for washing out.

73. *Fire pump.*—The fire pump to be of the outside packed plunger pattern of make approved by the engineer officer in charge, and to have a capacity of at one hundred gallons per minute. A main pipe line to be placed as convenient have hose connections on each side of dredge on each deck. Connections also made to sand chambers of main pump stuffing boxes, to spud anchor, and to tank on upper deck. Steam connections to be made from both main and auxi boilers. Four lengths of 2½ inch diameter best 4-ply rubber hose, each 50 feet with all necessary couplings, caps, nozzles, and valves to be supplied; also hose with chains attached and suitable racks for hose.

74. *Pipes, valves, etc.*—All the pipes, valves, and fittings necessary to complet dredge and put it in thorough working order must be supplied, of the very quality and of make approved by the engineer officer in charge. All small v up to and including 2½ inches diameter to be of brass, heavy pattern, and all v above 2½ inches diameter to be brass mounted and of heavy pattern. Steam and pipes to be made and fitted in accordance with the requirements of the rules o "Board of Supervising Inspectors," special attention being paid to making prov for the expansion and draining of said pipes. All main steam pipes and prin connections to be covered with good, nonconducting material, to be approved b engineer officer in charge.

75. *Electric-light plant.*—A complete electric-light outfit must be supplied installed; all parts of the same to be of make approved by the engineer offic charge. It will consist of an automatic engine and dynamo directly connect search light of 4,000 candle power, with necessary attachments for working from operating platform, 2 arc lights each of 1,200 candle power, and 75 incande lights each of 16 candle power. The engine and dynamo to have 25% more cap than is required for the above lights. The requisite rheostats, switch board wi its attachments, lamp holders and shades, and all other appurtenances for a plete and efficient installation to be supplied. The wiring and fittings to be o best description and done in a thoroughly good and workmanlike manner a strict accordance with the rules and requirements of the National Board of Underwriters. A detailed specification of this plant must be included in the ge specification called for in par. 41.

76. *Workshop and machine tools.*—A workshop to be fitted up on board and vided with the following machine and other tools, all of make approved by the neer officer in charge:

One 20-inch swing screw cutting slide lathe with compound rest and feed. Bed 14 feet long. Lathe to be provided with full set of change g large and small face plates, one 18-inch four-jaw chuck, one 9-inch thre chuck, steady and following rests. The tail stock to have set-over for ing taper.

One 24 or 25 inch swing vertical drill press with back gear and power with quick return motion.

One 15-inch crank shaper, with swivel vise.

One bolt and pipe cutter, to cut bolts from ¼ inch up to 2 inches dian and pipes from ¼ inch up to 3 inches; with a full set of both bolt and pipe and of machine taps from ¼ inch to 2 inches.

One set of pipe taps from ¼ inch up to 2½ inches.

Three pipe cutters, Nos. 1, 2, and 3, to cut pipe from ¼ to 4 inch diameter

One blacksmiths' forge, not less than 24 x 30 inch, with hood and necessary smoke pipes, fixed in place.

One fan blower, not less than 3-inch outlet, with blast gate and pipes connected to forge.

One portable forge without hood, not less than 20 x 24 inch.

One anvil, weight 200 lbs.

One pipe vise, hinged, to take pipe up to three-inch diameter.

One full set of pipe tongs, Brown's adjustable tongs up to 3 inches and chain tongs above 3 inches.

Two machinists' parallel vises; one 4½-inch jaws and the other 5½-inch jaws.

Hammers.—One sledge, 14 lbs.; one sledge, 10 lbs.; one blacksmiths' hand hammer, 2 lbs.; two machinists' hand hammers, 1¼ and 1¾ lbs.; one copper or rawhide hammer.

A full set of blacksmiths' tongs and tools.

Twelve machinists' chisels of different sizes.

A full set of adjustable and solid wrenches, for all the machinery on board.

The workshop is to be fitted up with bench, lockers, and tool racks.

77. *Workshop engine.*—An engine, 7-inch cylinder, 9 or 10 inch stroke, must be provided for driving the shop tools, and must be furnished with steam from both main and auxiliary boilers. A main line of shafting and all machine countershafts, with all pulleys, hangers, and belts, must be supplied and fitted in place in complete running order.

78. *Traveling cranes.*—An overhead traveling crane must be provided in the main engine room, fitted with hand-power hoisting tackle of sufficient capacity to lift the heaviest piece of machinery; the framing must extend to edges of boat, so that crane can land the machinery on deck outside of house. Another traveling crane of smaller capacity must be placed over bow winches in convenient position for handling this machinery.

79. *Auxiliary boiler.*—A vertical boiler 42 inches diameter and 8 feet high, with submerged tubes, to be placed in boiler room and connected with electric-light engine, fire pump and shop engine, and furnished with all usual fittings, valves, and connections. This boiler to be made in accordance with the rules prescribed by the "Board of Supervising Inspectors" for a working pressure of 140 lbs. per square inch.

80. *Discharge pipes.*—The discharge from pump will be carried aft and out through stern of dredge and connected by a flexible joint to floating pipe line. This pipe line to be 1,000 feet long, made in sections of 50 feet each, connected together with suitable straps and pin joints to admit of the outlet being deflected 500 feet from axis of channel; the pipes to be 32 inches in diameter and made of tank steel ¼ inch thick, flush riveted on the inside, and the pontoons to which they are attached to be of tank steel $\frac{3}{16}$ inch thick; the pontoons to be divided by three (3) water-tight bulkheads and otherwise strengthened, as shown on drawing No. 14, and fitted with manhole covers and running boards. The connections between pipe sections to be 8-ply best Para rubber hose, having ¼ inch of pure rubber on the interior surface, and outside edges capped with rubber, and to be provided with wrought-iron bands for securing same, all as shown on drawing No. 15. Two hand winches to be placed on pipe line for the purpose of hauling in the swing lines, and each pontoon to have six cleats securely riveted on in convenient position for fastening lines. The end of discharge pipe to have a baffle plate securely attached, as shown on drawing No. 14.

81. *Weighing apparatus.*—For the purpose of ascertaining the proportion of sand that is being dredged, a short length of the discharge pipe will be connected with flexible rubber joints and hinge straps, one end of this pipe to be suspended from end of weighing lever by links working on knife-edge pins of hardened steel. The weighing levers are to be keyed on a cross shaft which is carried on standard brackets from keelsons. The levers to be steel castings, with counterbalance weights attached, and to be set at such an angle that center of weighing pipe is ⅜ inch above the center of fixed discharge pipe when water only is being pumped; and this position will constitute the zero mark on indicator. A suitable indicator to be made and placed in a convenient position where it can be seen by the engineer. The connections between weighing pipe and ends of fixed discharge pipe to be made of pure Para rubber hose molded to form shown on drawing No. 15, and each end secured by two wrought-iron bands.

82. *Velocimeter.*—The velocimeter shown on drawing No. 13 to be supplied, and will consist of two heavy brass pipes 1 inch inside diameter passing vertically through the discharge pipe, with two small cross tubes ¼-inch bore inserted in them at a distance of $4\frac{13}{16}$ inches from the upper inside surface of pipe. These tubes must be set very accurately on the longitudinal center line of discharge pipe, the after one pointing aft and the forward one pointing forward or towards the pump. The orifice of forward or pressure tube is to be protected by a movable bar working in a stuffing

box, which is withdrawn when velocity readings are taken. The 1-inch pipes to b
provided with stuffing boxes and cocks, all of brass and connected to gauge glasse
by ½-inch brass pipes and rubber tubing. The gauge glasses to be ⅝-inch diamete
and 10 feet long, connected at upper end by a brass tube and mounted on a neat hard
wood board, on which the scale is to be clearly marked.

83. *Anchorage.*—The dredge will be moored in position by bow and breast line
which will be attached to iron piles, the bow lines of ¾-inch steel rope passing ove
snatch blocks on "A" frame to winches described in paragraph 65, and the breas
lines of 1½-inch diameter manila rope going to capstans. There will be six 10-inc
piles and ten 7-inch piles required, made of wrought-iron tubing, put together a
per drawing No. 16, and fitted with all clamps and hose connections ready for work

84. *Wire and other ropes.*—The following ropes to be supplied:

Two bow lines of ¾-inch diameter "Hercules" wire rope, 19 wires to th
strand, each 1,200 feet long.

One suction-frame hoisting rope of ¾-inch "Hercules" wire rope, 19 wires t
the strand, and 130 feet long.

One spud hoisting rope of ⅝-inch diameter "Hercules" wire rope, 19 wire
to the strand, and 36 feet long, with special thimble spliced in one end.

Four breast lines 1½-inch diameter, best manila rope, each 600 feet long.

85. *Spare parts.*—

1 set of steel plates for pump runner.
2 brass sleeves for shaft stuffing boxes of main pump.
2 wire-rope sheaves.
2 bronze worms for bow winches.
1 main rubber connection for discharge pipe at hull.
4 rubber connections for discharge pipe between sections.
8 clamps for rubber connections.
1 set of grate bars for one battery of boilers.

86. *Material and workmanship.*—The best quality of materials and workmanshi
will be required in each and every part of the work to be done under this specifica
tion, and no advantage shall be taken of any phraseology, error, or omission whic
would seem to justify other than these. Full information will be given upon an
point where doubt may arise.

87. *Character of material.*—All plates and angles to be used in the work under thi
contract, unless otherwise specified, will be of low steel 55,000 to 62,000 lbs. ultimat
tensile strength per square inch, elastic limit one-half of the ultimate strength
minimum elongation of 26 per cent in 8 inches, and minimum reduction of area a
fracture of 50 per cent. These tests will be made at the mill, from the steel of eac
heat, by inspectors designated by the engineer officer in charge and certified report
thereof transmitted to him. In addition to the above tests, partially cut but no
detached test pieces about 2 inches wide and 10 to 12 inches long must be furnishe
with at least two sheets out of the lot rolled from each heat; and tests thereof wil
be made by bending the metal back upon itself immediately after chilling from a
cherry heat by plunging into cold water. When so treated, the steel must show n
sign of fracture on the outside of the bent portion. In gauging the thickness, meas
urements will be made at each corner of plate and at different points throughou
the area. A variation of more than 2½ per cent above or below the specified thick
ness will cause plates to be rejected. Facilities must be furnished the inspector b
the manufacturers for making these tests, the cost of which will be borne by th
contractor. The rivets to be of soft steel not more than 61,000 lbs. nor less tha
55,000 lbs. ultimate tenacity, with an elastic limit of not less than 34,000 lbs., and a
ductility of not less than 26 per cent in ten diameters, and must be capable of bend
ing double flat without a sign of fracture on the convex side of the bend.

88. *Inspection.*—Inspectors will be appointed by the engineer officer in charge t
inspect, at the shops and on the dredge during the process of construction, the mate
rial furnished and the work done, and see that the same conforms strictly to speci
fications and requirements of the contract. The contractor must at all times give
the inspectors free access to the material and work, and afford every facility for
their inspections. The decision of the engineer officer in charge upon all questions
arising under these specifications shall be final, and he shall have the right to require
the immediate removal at any time of any employé of the contractor found incompetent or otherwise objectionable.

89. *Inspector's examination.*—Before beginning the tests, the inspectors appointed by the United States engineer officer in charge shall go over the dredge and plant carefully, to determine whether everything called for in the contract has been provided and is in proper working condition. No test shall begin until everything lacking shall have been supplied.

90. *Imperfect work.*—Any unfaithful or imperfect work, or defective or improper material, that may be discovered before the final acceptance of the dredge shall be corrected immediately. The inspection of the work and material during the process of construction shall not relieve the contractor of any of his obligations to perform good work and furnish good material as herein specified.

91. *Contractor's test.*—Prior to the commencement of the general efficiency test, the contractor shall satisfy himself of the proper operation of the dredge and of the sufficiency of each and every part by raising steam to the allowed limit and working each and every part as it is intended when the dredge is in full operation.

92. *Efficiency tests.*—Before the dredge is accepted a general efficiency test will be made, extending over a period of thirty days of 24 hours each, and the result of which will be determined by the percentage of lost time due to defects of the machinery when compared with the actual time available for dredging. The test will be made under the ordinary conditions of actual everyday work, and for this purpose the dredge shall be run to its full capacity and shall deliver its material through the full length of 1,000 feet of discharge pipe. The movements of the dredge and the selection of places where dredge is to be placed shall be entirely under control of the engineer officer in charge or his appointed agents. When the contractor is prepared to make the test, he shall notify the United States engineer officer in charge to that effect, and shall then hand over the dredge to the United States agents appointed to take charge. The tests will be made by the officers and crew selected by the engineer officer in charge, due consideration being given to any recommendations of the contractor as to competent employees, and at the expense of the United States Government. The contractor or his representatives may be present at all tests, and a copy of all records of tests shall be furnished him on application. An accurate log will be kept of all the operations of the dredge, recording the times at which the pump is stopped or started and a statement of the causes of each stoppage, from whatever source it may arise. All Sundays and holidays, time taken in towing and mooring, time lost in moving out of position for passing vessels and back again, and time occupied in making capacity tests, shall be deducted from the thirty days and the balance considered as "available dredging time," which shall form the basis for determining the percentage of "lost time," due to stoppage of any part of the machinery or plant which is the subject of the contract. The "lost time" taken during the whole period of thirty days of 24 hours each, shall not exceed twelve per cent (12 %) of the "available dredging time." In case this limit is exceeded, the dredge will be returned to the contractor, and the cost of the efficiency tests previously made will be deducted from any sums due or to become due the contractor. When the contractor notifies the engineer officer in charge that he has remedied the defects and is ready to commence new tests, the dredge will be returned to the Government agent and a second series of efficiency tests proceeded with in the same manner. It is to be understood that no repairs shall be made on Sundays or at times when the dredge is considered to be not at work, excepting such things as are ordinarily done at that time to keep the machinery in proper working order, as washing out boilers, packing stuffing boxes, tightening joints, stripping brasses, etc. The cost of all repairs during the efficiency tests shall be borne by the contractor.

93. *Capacity tests.*—During the progress of the efficiency tests, five tests will be made to ascertain the capacity of the dredge, of which the average result shall be adopted. This will be done by attaching one or more measuring barges to the end of the discharge pipe, the sand and water being delivered into them under such conditions and instructions as the engineer officer in charge may prescribe, following conditions of regular work as nearly as practicable. The dredge must deliver sand at the rate of 1,000 cubic yards per hour through 1,000 feet length of pipe, under the conditions prescribed. The material will be measured in place in the barges by cross sectioning at frequent intervals. These tests shall be made while the dredge is operating on a bar of sand of such fineness and freedom from clay and admixtures as are generally met with in actual practice.

94. *Penalty.*—But two series of efficiency tests and one series of capacity tests will be made. Should the dredge finally fail to meet the contract requirements as above prescribed, the right is reserved to either reject it or to accept it at such reduction in price as the engineer officer in charge, with the approval of the Chief of Engineers, U. S. Army, may find necessary in order to reimburse the United States for all damages sustained by reason of said failure, including the cost of all tests and the cost of remodeling the dredge so that it shall meet the contract requirements.

95. *Explanations and corrections.*—Any doubt as to the meaning of this specification or of any drawings or explanations that may be furnished the contractor, or any obscurity in the wording of them, will be explained by the engineer officer in charge, who shall have the right to correct any errors or omissions in them, when such correction is necessary for the proper fulfillment of their intention.

96. *Extra work.*—No claim for extra work or material, or for delay of any kind, will be considered or paid for unless an agreement therefor shall be made in writing and approved by the Chief of Engineers, U. S. Army. The contract price is to be full compensation for furnishing all materials, labor and appliances necessary for doing all the work, and furnishing the dredge herein specified.

97. *Port of delivery.*—The dredge to be delivered at Cairo or Memphis, at the option of the contractor.

98. *Time of delivery.*—The dredge must be completed in all and every part, a handed over to the United States engineer officer in charge for test, within nine (months from the date of notification of approval of contract. If there be no del caused by defective or imperfect machinery developed during the efficiency te rendering necessary a second series, the date of the commencement of this test w be considered as the date of the delivery of the dredge. Should there be dela from the causes above mentioned, rendering necessary a second series of efficien tests, the date of delivery will be taken as that on which the dredge is turned ov to the engineer officer in charge for the new tests.

99. *Interpretation of terms.*—In case of any disagreement concerning the interp tation of the provisions of this specification, the decision of the United States en neer officer in charge shall be binding.

100. *Patents.*—The contractor shall guarantee the Government against any clai or awards for damage on account of the infringement of any patented device whi he shall furnish to the dredge.

101. *Omissions, etc.*—All necessary adjuncts, parts, or attachments properly for ing a part of the dredge, and requisite for the proper and efficient working of t machinery, shall be understood to be included in these specifications, wheth mentioned herein or not, and shall be supplied by the contractor as forming part the contract. And it shall be further understood that, notwithstanding the gene drawings are furnished by the United States, the contractor shall be responsible the strength and efficiency of all details, except in cases where special materia dimensions, and arrangements are specified and full detailed drawings of constr tion are provided.

No. 2.—*Specification of hydraulic dredge with mechanical agitators.*

102. This specification shall be known as Specification No. 2, October 12, 1896, a shall relate to the construction of a dredge having "mechanical agitators" to s up the sand at mouth of suction pipes.

103. This dredge will be a duplicate of that described under Specification No. October 12, 1896, except in such points as are rendered necessary by the difference the "agitators," and shall be subject to all the provisions of said specification, exce as herein modified.

104. Proposals must be accompanied by full drawings and specifications of t "agitators" offered, showing clearly what alterations, if any, will be required the arrangement of machinery called for under Specification No. 1, October 12, 18 An estimate of the weights of "agitators" and machinery must also be submitt

105. It shall be optional with bidders for this dredge to make hull as much wid as may be required to maintain the stipulated draft of 48 inches, but it is desiral to keep to all other dimensions given on plans for dredge under Specification No. October 12, 1896. The width of the well in which the cutters work at its forwa end shall not be more than 32 feet.

106. The same general efficiency and capacity tests will be adopted as are prescrib for dredge under Specification No. 1, October 12, 1896, but, in the efficiency tes the percentage of "lost time" allowed will be taken as fifteen per cent (15% instead of twelve per cent (12%), of the "available dredging time." In case of fa ure to meet the contract requirements, the contractor will be subject to the penal prescribed in paragraph 94, including among the damages sustained the cost removal of the "mechanical agitators" and appurtenances and substitution there of the "water-jet agitators" and pump above described, if such a change is deem advisable.

Appendix.—Dredge with water-jet agitators.

Approximate weights of machinery:	Poun
Hull	440,0
One inch of water in hull	26,0
Deck house and cabins, with fittings	120,0
Hull fittings, viz: bitts, chocks, kevils, siphons, etc	10,0
Two traveling cranes and lifting tackles	14,0
Main pump and compound engine	110,0
Jet pump and compound engine	19,5
Feed and fire pumps	5,0
Heater and pump well	8,0
Dynamo and engine	4,0
Shop engine	2,5
Shop tools, shafting, etc	21,0
Two bow-line winches	22,0
One suction-frame hoisting winch	5,0
One spud anchor and winch	12.0
Suction-pipe frame, radial joints, and straining frame	35,0
"A" frame and suspension tackle	13,8
Suction and discharge pipes in hull	22,0

Approximate weights of machinery—Continued.	Pounds.
Steam, feed, and all other piping, with valves and covering for same.	28,000
Four steam capstans	11,200
Wire rope	2,400
Two batteries of boilers, complete	190,000
Water in boilers	60,000
Water in discharge pipes	32,000
Water in feed and fire pipes	7,000
Auxiliary boiler, complete	5,000
Coal in bunkers	60,000
Equipment, small tools, stores, spares	24,000
Total weight	1,309,400

Average displacement of hull per 1 inch of draft up to 48 inches draft=27,730 pounds.

Displacement per inch over 48 inches draft=28,020 pounds.

Total displacement equal $\frac{1,309,400}{27,730}=47.22$ inches.

Drawing No. 4 shows distribution of weights in hull.

Summary of data of calculation used in designing dredge:

Requirements, 1,000 cubic yards of sand, to be delivered through 1,000 feet of pipe 32 inches diameter, at a velocity of 13 feet per second.

Capacity of pump:

Area 32-inch discharge pipe=5.58 square feet.

Discharge at 13 feet per second=4,352 cubic feet per minute.

And 4,350 cubic feet per minute=9,670 cubic yards per hour.

Percentage of 1,000 yards of sand to 9,670=10.34.

Head of water:	
Friction head for total length of 1,150 feet of pipe	22.2
Velocity head	2.7
Suction head (assumed)	7.0
Elevation	1.0
Total head	32.9

(say 33 feet).

Power required:

Weight of 90 per cent water and 10 per cent sand=68 pounds per cubic foot; then $\frac{4350\times 68\times 33}{33,000}=296$, or, say, 300 horsepower.

If efficiency of pump is taken at 50 per cent, the gross indicated horsepower of engines will be $\frac{300}{.50}=600$ for average running, or $600+15$ per cent$=690$ indicated horsepower maximum.

Boilers—evaporation required:	
Main engines, compound, noncondensing, maximum 690 horsepower, at 25 pounds of water per hour	17,250
Jet-pump engines, 80 horsepower, at 25 pounds	2,000
Bow-winch engines, 30 horsepower, at 40 pounds	1,200
Fire and feed pumps, 10 horsepower, at 40 pounds	400
Electric-light engine, 10 horsepower, at 30 pounds	300
	21,150

Boilers assumed to evaporate 8 pounds of water per pound of coal per hour, with exhaust in chimney; then coal consumption will be $\frac{21150}{8}=2,644$ pounds of coal per hour.

Coal burned per square foot of grate per hour, with exhaust in chimney, taken at 18 pounds; then $\frac{2644}{18}=147$ square feet area of grate required.

Two furnaces 13 feet wide each and grate bars 5¼ feet long=143 square feet grate area.

Six "Mississippi" boilers 48 inches diameter, 28 feet long, with five 11-inch flues in each, give 3,084 square feet effective heating surface, and $\frac{3084}{143}=21.5=$ratio of heating surface to grate area.

H. E. WATERMAN,
Captain, Corps of Engineers,
Secretary Mississippi River Commission.

MISSISSIPPI RIVER COMMISSION,
Office of the Secretary, St. Louis, Mo., October 12, 1896.

APPENDIX 7 C.

REPORT OF CAPT. H. E. WATERMAN, CORPS OF ENGINEERS, SECRETARY MISSIS RIVER COMMISSION, UPON DREDGING OPERATIONS ON THE MISSISSIPPI R BETWEEN CAIRO, ILL., AND MEMPHIS, TENN., DURING LOW-WATER SEASON OF

MISSISSIPPI RIVER COMMISSION,
OFFICE OF THE SECRETARY,
St. Louis, Mo., April 13, 18

COLONEL: I have the honor to submit the following report of dredging opera in the lower Mississippi by the plant under my charge during the low-water se of 1896:

PROJECT.

The project under which the season's work was planned is that specified i act of Congress of June 3, 1896, requiring the operation of suitable dredge boat other appliances, with a view of ultimately obtaining and maintaining a navi channel from Cairo down not less than 250 feet in width and 9 feet in depth periods of the year except when navigation is closed by ice.

ORGANIZATION.

As but two dredges, the *Alpha* and *Beta*, were available, it was decided to l both between Cairo and Memphis, and to start the *Alpha* from Cherokee Cro (89 R) and the *Beta* from Memphis (230 L), both dredges to work upstream as ra as possible, deepening all bars on which the probable low-water depth would b than 9 feet. In order to concentrate the work as much as possible, no prov was made for any dredging below Memphis, but fortunately the stage of throughout the summer and fall was such that no difficulty was met with in portion of the river.

The available plant was divided between the two parties as follows:

With the dredge *Beta* 1 large tender (the steamer *Minnetonka*), 1 small te (the steamer *Vidalia*), 1 quarter boat, 1 machine-shop boat, 1 pile sinker, 2 barg

With the dredge *Alpha* 1 large tender (the steamer *Mississippi* and durin absence the steamer *Fred. Hartweg*), 1 pile sinker, 3 barges.

The dredging force was organized as shown in the tabulated statement belo

Table showing organization of force engaged in dredging operations during the low- season of 1896.

	Alpha.				Beta.				
	Dredge (double crew).	Pile sinker (single crew).	Large tender (single crew).	Total.	Dredge (double crew).	Pile sinker (single crew).	Large tender (single crew).	Small tender (single crew).	Total.
Assistant engineers	1	......	......	1	1	......	......	......	1
Masters	1	......	1	2	1	......	1	1	3
Mates	1	......	1	2	1	......	1	1	3
Steam engineers	2	1	1	4	5	1	1	1	8
Master laborers	2	1	......	3	2	1	......	......	3
Machinists	1	......	......	1	......	......	......	......	......
Blacksmiths	......	......	......	......	1	......	......	......	1
Carpenters	1	......	......	1	1	......	......	......	1
Strikers	2	......	......	2	......	......	......	......	......
Firemen	4	......	2	6	10	......	2	2	14
Watchmen	......	1	1	2	......	1	1	......	2
Oilers	2	......	......	2	6	......	......	......	6
Deck hands	5	1	2	8	4	1	1	1	7
Stewards	1	......	......	1	1	......	......	......	1
Cooks	2	......	1	3	2	......	2	1	5
Waiters	3	......	......	3	3	......	1	1	5
Laundresses	1	......	1	2	1	......	1	1	3
Surveyors	1	......	......	1	1	......	......	......	1
Rodmen	1	......	......	1	2	......	......	......	2
Laborers	11	3	2	16	16	3	2	2	23
Total	42	7	12	61	58	7	13	11	89

DETAILED REPORT OF OPERATIONS.

The entire dredging plant, which was lying at Memphis with the fleet of the first and second districts, was put in commission on August 28. The operations of the dredge *Beta*, in charge of Assistant Engineer C. W. Sturtevant, will first be described in detail, and afterwards those of the dredge *Alpha*, in charge of Assistant Engineer Peter Mogensen.

CHUTE OF ISLAND NO. 40 (211 L).

The *Beta* arrived at the chute of Island 40 (211 L) August 30. A survey was made of the crossing, and dredging was begun on the morning of September 1. The stage of the river at that date was 8 feet on the Memphis gauge, and it was falling at the rate of about 0.4 foot per day. The depth of water on the crossing was about 10 feet. The lowest stage during the season was 1.8 feet on the Memphis gauge, and occurred on September 20. When dredging work began the distance between the 9-foot curves in the upper and lower pools, with the soundings reduced to the lowest stage of the season, was 1,300 feet, with a practicable channel 6 feet deep at the same stage.

After cuts aggregating 2,000 in length had been made on September 2 both lines of floating pipes suddenly capsized. The pipes at the time were deflected at an angle of about 40 degrees from the direction of the current, the velocity of this current being about 4.3 feet per second. It is supposed that the capsizing began at the lower end and that the upstream line of pipe turned upstream and the other line downstream. The pipes shortly afterwards sank in about 15 feet of water. Two hundred and twenty-four and one-half hours' time was consumed in pumping out, repairing the pipes, and placing the plant in position, and dredging was again begun on September 13 at noon.

The water ahead of the dredge averaged about 8 feet in depth, and the cutters were lowered to a depth of 15 or 16 feet; but although the cutters were working to a depth of about 6 feet below the bed of the river, the effective increase in depth found at the stern of the dredge was scarcely half this amount. On account of leaks in one of the boilers, caused by blowing out of the gaskets around the hand-hole plates, only three batteries of boilers were used on the last day's work.

All of the cuts, ten in number, were completed on September 18, and the plant was moved to the foot of Island 34 (179 R). The cuts aggregated 5,945 feet in length. The total number of hours of actual dredging was 121, and the average forward movement while dredging was 49.1 feet per hour. The material dredged consisted of medium coarse sand, with gravel and clay lumps beneath. In places the gravel was very compact and hard. At three points snags were encountered, which could not be removed by the cutters, and the cutters were raised and moved to the upper side of the snags.

The area actually covered in dredging was 1,325 feet long and about 160 feet wide at the lower end, 225 feet wide near the middle, and 120 feet wide at the upper end, giving a superficial area of about 182,694 square feet.

The changes that are constantly going on in the channel make all determinations of the amount of material removed by the pumps based on surveys very uncertain. If we consider an area 2,000 feet long and 400 feet wide on each side of the axis of the dredging, the surveys before and after dredging would indicate that 176,370 cubic yards of material had been removed in 121 hours' dredging, or at the rate of 1,458 cubic yards per hour. The total cost of this work, including the delay occasioned by the overturned pipes and towing to the next bar, was $6,122.51. Taking the yardage as given above, the cost per cubic yard would be about 3½ cents.

The cost of work at Island No. 40 and other details concerning the operations at this bar are found in the tables immediately following:

Dredge Beta.—Cost of work at Island No. 40, August 31 to September 24, 1896.

Labor	$3,378.29
Subsistence	752.35
Fuel	1,797.35
Engineer's supplies, miscellaneous	33.27
Engineer's supplies, oil	38.95
Mate's supplies	12.92
Repairs	69.54
Lighting supplies	21.48
Miscellaneous	4.88
Stationery and office supplies	1.84
Freight	.90
Laundry supplies	10.74
Total	6,122.51

Dredge Beta.—Summary of operations at Island No. 40 (211), August 31 to September 24, 1896.

Date.	Conditions of work.														Distribution of time.									Remarks.
	Cuts.					Average depth.				Heads.		Revolutions (average per minute).		Steam pressure.										
	Number.	Length.	Time.	Rate per hour.	Material.	Suction.	Ahead of dredge.	Astern of dredge.	Material removed.	Suction.	Delivery.	Pumps.	Cutter engines.		Placing plant.	Dredging.	Changing cuts.	Repairs.	Passing boats.	Making up tow.	Towing.	Sundays and holidays.	Total.	
1896.		*Ft.*	*Hrs.*	*Ft.*		*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	
Aug. 31															17							7	24	Local gauge 10 feet.
Sept. 1	1	325	2.75	119	F. S.	15	10.5	14	3.5	14.125	20	125	125	160	5.5	9	0.5	9					24	Commenced dredging at 5.30 a. m. Local gauge 9.6 feet.
1	2	550	5	110																				
1	3	225	1.25	180																				
2	3	325	4.75	68	do	16	10	13.5	3.5	13.56	20.5	121	118	157		10	1.75	3.75					15.5	Vel. of current 4.3 feet per sec. Local gauge 9.3 feet.
2	4	425	5.25	81																				
12															19				1	2	2		24	Local gauge 4.2 feet.
13	5	675	12	56	M. F. S.	15	8	13.5	5.5	13	19	131	132	165	12	12							24	
14	5	85	1.5	57	do	15.5	8	13.5	5.5	15.25	22.8	133	130	167		14.5	9.5						24	Vel. of current 5.4 feet per sec.
14	6	800	13	62																				
15	6	100	3	33	C. S.	16	8.5	14	5.5	15.25	17.9	134	120	171		22	2						24	
15	7	575	19	30																				
16	7	200	5.5	36	C. S. & G.	15	8.7	12.5	3.8	15.82	18	135	111	163		21	3						24	Capsized pipes caused a loss of 224½ hours, September 2 to 11.
16	8	450	15.5	29																				
17	9	500	11	45	do	15	9	13	4	16.04	19.2	132	124	160		19.5	4.5						24	
17	10	200	8.5	24																				
18	10	510	13	39	do	15	10.5	12.5	2	12.43	15.7	125	104	145		13	4			1		6	24	Using only 3 batteries of boilers.
19																				24			24	
20																				12	12		24	Local gauge 2.4 feet.
21																					24		24	
22																					24		24	
23																					24		24	
24																					18	6	24	Plant arrived at Island No. 34.
Total	10	5,945	121												53.5	121	25.25	12.75	1	39	104	19	375.5	
Average				40.1		15.3	9.2	13.4	4.2	14.43	19.1	129	120	161										
Per cent															14.30	32.25	6.75	3.40	0.05	10.40	27.75	5.10	100	

NOTE.—F. S. = fine sand; M. F. S. = medium fine sand; C. S. = coarse sand; C. S. & G. = coarse sand and gravel.

ISLAND NO. 34 (179 R).

The *Beta*, with dredging plant, arrived at Island No. 34 on September 21. A survey was made on September 23 and it was decided to open the channel down the island shore instead of following the existing steamboat channel which made a sharp crossing to the left bank and then back again to the right bank at Morgans Point. The channel selected practically eliminated two crossings and showed 10 feet of water except for a distance of about 300 feet, where there was only 8 feet. The upper pool was over 400 feet in width while the lower pool for a distance of 3,000 feet narrowed down in places to about 200 feet wide, but the channel was straight and easy to run.

Dredging was begun on September 25 at a point about 1,800 feet above the foot of the island and 1,000 feet from the shore. After a short run it was discovered that the valve rod of the starboard pumping engine was bent. Repairs were completed and another run of about six hours was made when the starboard engine stopped owing to the dropping down of the valve seat in the high-pressure steam chest. This caused another delay of about seven hours, after which the dredge was again started and Cut No. 1 finished. On examination of the suction a 6-inch cottonwood limb was found which had been cut off by the cutters.

Work was begun on Cut No. 2 at 3.30 p. m. on September 26. After a run of about five hours the connecting rod on the low-pressure cylinder of the cutter engines broke. After this, dredging was continued without the use of the cutters. On September 27 there was three hours' delay on account of repairs to the hoist and keying the rocker arm on valve motion of starboard pumping engine.

Work at this crossing was completed at 6 a. m. September 29, and the plant was moved to Osceola Bar (164.5 L). Two cuts, nearly parallel, were made about 40 feet apart and aggregating 2,275 feet in length. The total number of hours of actual dredging was sixty-six. More than half this work was done without the use of the cutters. Under these conditions the rate of advance was only about 24 feet per hour, but the depth of submersion of the floating pipes indicated that they were loaded to about the same extent as when the cutters were in operation.

The material at this crossing was coarse sand and gravel. The cutters were lowered to a depth of about 15½ feet. The superficial area of the two cuts is about 51,000 square feet.

Computing the amount of material removed in the same manner as in the case of Island No. 40, we have for an area 2,200 feet long and 800 feet wide a total of 91,852 cubic yards, or an average of 1,392 cubic yards per hour. The total cost of this work, including towing to the next bar, was $1,793.42, which would give for the yardage above estimated a cost of about 2 cents per cubic yard removed.

While this work was in progress the river rose 1.5 feet.

The details of the cost and work at this bar are given in the following tables:

Dredge Beta.—Cost of work at Island No. 34, September 25 to 30, 1896.

Labor	$795.82
Subsistence	169.56
Fuel	579.15
Engineer's supplies, miscellaneous	17.72
Engineer's supplies, oil	13.91
Mate's supplies	5.52
Repairs	199.03
Lighting supplies	6.27
Miscellaneous	2.61
Stationery and office supplies	.59
Laundry supplies	3.24
	1,793.42

Dredge Beta.—Summary of operations at Island No. 34 (179), from September 25 to 30, 1896.

Date.	Conditions of work.														Distribution of time.							Remarks.
	Cuts.					Average depth.				Heads.		Revolutions (average per minute).										
	Number.	Length.	Time.	Rate per hour.	Material.	Suction.	Ahead of dredge.	Astern of dredge.	Material removed.	Suction.	Delivery.	Pumps.	Cutter engines.	Steam pressure.	Placing plant.	Dredging.	Changing cuts.	Repairs.	Making up tow.	Towing.	Total.	
1896.		*Feet.*	*Hrs.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*				*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	
Sept. 25	1	210	3.5	60	C. S. & G.	15.5	9.5	13	3.5	14.12	19.8	131	126	161	16.5	3.5		4			24	Local gauge 10.6′.
26	1	590	6.5	91	do	16	9	13.5	4.5	14.46	23.7	131	123	165		15	1.5	7.5			24	Cutter engines failed at 3.30 p. m.
26	2	190	8.5	22																		
27	2	485	21	23	do	16	10	13.5	3.5	16.49	22.7	133		164		21		3			24	Without cutters. Local gauge 11.35′.
28	2	540	22	25	do	15	9.7	13.5	3.8	15.59	21	133		168		22	2				24	Without cutters. Local gauge 11.60′.
29	3	250	4.5	55	do	15	10	14	4	15.59	20.7	135		165		4.5	1.5		6.5	11.5	24	Without cutters. Local gauge 11.50′. Fulton gauge 6.25′.
30																				14	14	
Total	3	2,265	66												16.5	66	5	14.5	6.5	25.5	134	
Average				34.3		15.6	9.5	13.5	4	15.25	21.6	134	125	165								
Per cent															12.3	49.3	3.7	10.8	4.9	19	100	

NOTE.—C. S. & G.=Coarse sand and gravel.

OSCEOLA BAR (164.5 R).

The dredge *Beta* with plant arrived at Osceola Bar (164.5 R) on September 30, and an examination of the crossing was at once made for the purpose of selecting the best location for dredging.

Dredging began at 1 a. m. October 1. The connecting rod of the cutter engines had been repaired and was replaced and the cutters started. The material encountered was medium fine sand, the depth at the head of the dredge being about 9 feet and the cutters were lowered to 15 feet. The lower edge of the reef at this bar was very steep and dropped suddenly from 9 feet to 24 feet. The current in the lower pool flowed at a sharp angle with the reef, thus adding to the difficulty of starting the cut. Short irregular cuts were therefore made in order to open the reef sufficiently to allow the dredge to enter straight with the current.

Prior to this time dredging had only been done with the dredge pulled upstream. In order to meet the difficulty of mounting the bar, it was determined to attempt working downstream over the reef, which on first trial proved entirely successful. Instead of hoisting the cutters and dropping back without dredging, the boat was dropped down with the head or bow still upstream, but with the dredge in full operation. This method enabled the first cut to be put through without any difficulty from the dredge swinging off the line, and it was found to save material time in changing cuts, as the dredge could be worked on one cut downstream and on the next cut upstream without stopping pumping or even raising the cutters. Another important advantage that was found by this method of dredging is that the cuts are left deeper when the dredge is working downstream than when working upstream. This is due to the fact that the shoaling caused by the retardation of the current under the hull of the boat is with the downstream method entirely removed, as the suction and cutters follow the boat, whereas with the upstream method such is not the case, as the boat follows the suction and cutters.

The cuts at this place covered a width of about 200 feet in the widest place, and the greatest length was 1,350 feet. The work was finished at 7 a. m. October 4, and the plant was moved to Hathaways (102 L). The aggregate length of all the cuts was 5,660 feet, and the total number of hours of actual dredging was 63¾, or an average of 89 feet per hour.

Using an area of 800 by 2,300 feet, or 1,840,000 square feet, in computing the yardage of material removed, we find a total of 65,555 cubic yards, or an average of 1,028 cubic yards of material removed per hour of actual dredging. The total cost of work at this bar, including towing to the next bar, was $2,379.05, making the average cost per cubic yard removed as estimated above about 3.6 cents.

While this work was in progress the river fell about 1 foot.

The cost of the work and details of the operations are given in the following tables:

Dredge Beta—Cost of work at Osceola Bar, September 30 to October 9, 1896.

Labor	$1,362.06
Subsistence	239.01
Fuel	690.19
Engineer's supplies, miscellaneous	16.79
Engineer's supplies, oil	18.86
Mate's supplies	4.85
Repairs	33.03
Lighting supplies	6.98
Miscellaneous	2.09
Stationery and office supplies	.70
Laundry supplies	4.49
	2,379.05

Dredge Beta.—Summary of operations at Osceola Bar (164.6), September 30 to October 9, 1896.

Date.	Conditions of work. Cuts. Number.	Cuts. Length.	Cuts. Time.	Cuts. Rate per hour.	Cuts. Material.	Average depth. Suction.	Average depth. Ahead of dredge.	Average depth. Astern of dredge.	Average depth. Material removed.	Heads. Suction.	Heads. Delivery.	Revolutions (average per minute.) Pumps.	Revolutions (average per minute.) Cutter engines.	Steam pressure.	Distribution of time. Placing plant.	Dredging.	Changing cuts.	Repairs.	Making up tow.	Towing.	Sundays and holidays.	Total.	Remarks.
1896.		*Feet.*	*Hrs.*	*Ft.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*				*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	
Sept. 30															10							10	Local gauge 10′.
Oct. 1	1	a 220	5.75	38	F. S.	15	9	14	5	14.57	17.7	187	116	166	1	19	2	2				24	Without cutters up to 3 p. m. Local gauge 9.80′.
1	2	a 280	13.25	21																			
2	2	a 10	.50	20	F. S.	15	9	14	5	15.14	21.3	135	114	165		20	4					24	Local gauge 9.65′.
2	3	a 335	9.10	37																			
2	4	a 400	8.70	46																			
2	5	a 180	1.70	106																			
3	5	a 360	3.50	103	F. S.	15	9.5	13.5	4	15.59	21.3	134	127	166		17.75	1.75	4.5				24	Local gauge 9.40′.
3	6	590	5.20	111																			
3	7	1,290	4.80	270																			
3	8	650	4.25	151																			
4	8	385	3	128	F. S.	15	9.5	13	3.5	15.59	22.3	135	120	173		7			7		10	24	Local gauge 9.10′.
4	9	960	4	240																			
5																			13.5	10.5		24	Local gauge 8.90′.
6																				24		24	
7																				24		24	
8																				24		24	
9																				15		15	
Total	9	5,660	63.75												11	63.75	7.75	6.50	20.50	97.50	10	217	
Average				89		15	9.4	13.5	4.1	15.22	20.77	135	119	167									
Per cent															5.1	29.4	3.6	3	9.4	44.9	4.6	100	

NOTE.—F. S.=Fine sand.

a Estimated.

HATHAWAYS LOWER CROSSING (102 L).

Part of the dredging plant arrived at Hathaways on October 7, and a survey of the locality was made on October 8. The remainder of the plant arrived at 3 p. m. on October 9, and the *Beta* began dredging at 2 p. m. Monday, October 10. Dredging was continued without stopping or slowing down the pumps until 5 a. m. on October 14, when the work at this point was completed. This made a continuous run of 87 hours.

The first tow left for Cherokee (89 R) at 10.30 a. m. October 14. Sixteen cuts in all were made with a total length of 12,175 feet, which gives an average rate of 140 feet per hour, the dredge working up and down alternately. It was estimated that this method of working effected a saving of 30 hours at this bar.

The area covered by the cuts measured about 1,600 feet long by 275 feet wide. About midway of the length the cuts were bent downstream at an angle of about 20 degrees, so that the flow would more nearly coincide with the direction of the current in the lower pool. The velocity of the current was less than 3 feet per second, and had but little effect in removing the compact bed of sand and gravel.

For computing the volume of material removed the area considered is 2,400 feet long by 800 feet in width. This gives a total of 80,592 cubic yards, or an average of 926 cubic yards per hour. The total cost of the work at this bar, including towing to the next one, was $1,671.59, or a little over 2 cents per cubic yard. During this run the dredge burned 7,782 bushels of Pittsburg lump coal, or about 89½ bushels per hour.

The following tables give the details of the cost of work done at Hathaways Lower Crossing (102 L):

Dredge Beta.—Cost of work at Hathaways Lower Crossing, October 10 to 15, 1896.

Labor	$788.89
Subsistence	138.51
Fuel	675.59
Engineer's supplies, miscellaneous	14.56
Engineer's supplies, oil	16.61
Mate's supplies	6.89
Repairs	16.37
Lighting supplies	7.06
Miscellaneous	2.54
Stationery and office supplies	.60
Freight	.60
Laundry supplies	3.37
	1,671.59

Dredge Beta.—Summary of operations at Hathaways Lower Crossing (102 L), October 9 to 15, 1896.

Date.	Conditions of work.														Distribution of time.					Remarks.
	Cuts.					Average depth.				Heads.		Revolutions (average per minute).								
	Number.	Length.	Time.	Rate per hour.	Material.	Suction.	Ahead of dredge.	In wake of dredge.	Material removed.	Suction.	Delivery.	Pumps.	Cutter engines.	Steam pressure.	Placing plant.	Dredging.	Making up tow.	Towing.	Total.	
1896.		*Feet.*	*Hours.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*				*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	
Oct. 9															9				9	Local gauge 11.6'.
10	1	970	7.75	125	C. S. & G.	19	13.5	17.5	4	15.37	21.5	130	144	160	14	10			24	Local gauge 12.7'.
10	2	225	2.25	a 100																
11	2	750	4.75	a 158	...do	20	14.5	18.5	......	15.08	24.4	136	125	159	......	24			24	Local gauge 14.3'.
11	3	975	8.40	116																
11	4	1,040	4.25	a 245																
11	5	1,035	6.60	157																
12	6	950	5	a 190	...do	21	15.5	19.5	4	14.69	25.3	135	128	162	......	24			24	Local gauge 15'.
12	7	730	8.70	84																
12	8	775	4.80	161																
12	9	630	5.50	a 119																
13	10	630	2.75	229	...do	21	15	18.5	3.5	15.37	23	135	122	158	......	24			24	Local gauge 15.4'.
13	11	720	2.50	a 288																
13	12	720	3.25	222																
13	13	620	6.70	a 93																
13	14	620	6.30	98																
13	15	300	2.50	a 120																
14	15	290	3.20	91	...do	21	15	19.5	4.5	14.69	23	135	142	163	......	5	5.5	13.5	24	Local gauge 15.45'.
14	16	195	1.80	108																
15																		14.5	14.5	
Total	16	12,175	87												23	87	5.5	28	143.5	
Average				140		20.5	14.8	18.7	3.8	15.08	23.4	134	132	160						
Per cent															16	60.6	3.9	19.5	100	

NOTE.—C. S. & G. = Coarse sand and gravel.

a Cuts made downstream.

CHEROKEE CROSSING (89 R)—SECOND TIME.

The *Alpha* at this time had already done work at Cherokee Crossing, but this had been partially obliterated by the encroachment of a bar above, and the *Beta* was ordered to the same point to open a channel lower down.

The plant arrived on October 14 and a survey was made the following day. The river at the time was just at the top of a rise some 6¼ feet above the lowest water of the season. I made an inspection of the dredge *Beta* at this bar, reaching the fleet about 4 o'clock on October 15. At the time of my arrival the second tow had not reached Cherokee and nothing was in progress except surveys of the locality. The *Alpha's* channel still had a fair depth, but had been narrowed from the encroachments of the bar to such an extent that it was not believed safe to attempt to reopen it on the same line.

The second tow did not reach there until nearly 6 o'clock, when the plant was taken out into the river, placed in position, piles jetted down, and floating pipes connected. In anchoring the dredge no use whatever was made of the spuds, as the cutters, when lowered, answered the purpose much better. In fact, the spuds were not lowered at all except in order to lift the stern end of the dredge while the connection to the pipe line was being made. At midnight on October 15, six hours after the beginning of the placing of the plant, dredging began and was continued for 39 hours without stopping. The organization of the party was excellent. Every man seemed to have his work assigned to him and to know exactly what was necessary to be done.

During the first 24 hours 4 cuts 500 feet in length were made, or a total of 2,000 linear feet, in a compact bed of sand and coarse gravel, the cutters working to a depth of about 5 feet in this material. The first cut in this case, as before, was made downstream.

On October 17 the work was delayed by an accident to the bevel gear wheels at the upper end of the cutter shaft. The teeth were stripped from these wheels, owing to the breaking of a journal-box bolt on the forward end of the ladder shaft. New gears were put on and dredging resumed at 1 a. m. on October 18. Work was continued without stopping until 4 p. m. October 19, when operations were suspended on account of the stage of the river, which was considered such as to make dredging unnecessary. At this time two-thirds of the work needed to make a good channel had been completed. The plant was tied up to the bank in the immediate vicinity and the entire crew retained awaiting developments as to further work.

Eleven cuts were made, aggregating 6,435 feet in length and covering an area of about 1,450 feet long and 180 feet wide. The total number of hours of dredging was 78¼, and the average rate was, therefore, about 82 feet per hour.

For computing the volume of material moved an area of 2,500 feet by 800 feet has been taken. This gives a total of 62,000 cubic yards, or an average of 795 cubic yards per hour. The cost per yard on this basis would be 2.8 cents.

The cost of this work and the details of the operations of the dredge *Beta* at Cherokee Crossing between October 16 and 19 are given in the following tables:

Dredge Beta—Cost of work at Cherokee Crossing, second time, October 16 to 19, 1896.

Labor	$909.21
Subsistence	168.15
Fuel	588.22
Engineer's supplies, miscellaneous	19.86
Engineer's supplies, oil	11.84
Mate's supplies	7.64
Repairs	23.69
Lighting supplies	8.03
Miscellaneous	1.94
Stationery and office supplies	.38
Freight	.60
Laundry supplies	3.02
	1,742.58

Dredge Beta.—Summary of operations at Cherokee Crossing (89 R), October 15 to 24, 1896.

Date.	Conditions of work.															Distribution of time.						Remarks.
	Cuts.					Average depth.				Heads.		Revolutions (average per minute).		Steam pressure.								
	Number.	Length.	Time.	Rate per hour.	Material.	Suction.	Ahead of dredge.	In wake of dredge.	Material removed.	Suction.	Delivery.	Pumps.	Cutter engines.			Placing plant.	Dredging.	Repairs.	Making up tow.	Towing.	Total.	
1896.		Feet.	Hrs.	Feet.		Feet.	Feet.	Feet.	Feet.	Feet.	Feet.					Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	
Oct. 15																9.5					9.5	Local gauge, 10′.
16	1	500	5.50	a 91	C. S. & G.	17	11	16	5	14.69	21.9	184	123	161			24				24	Local gauge, 9.4′.
16	2	500	5.25	95																		
16	3	500	6.75	a 74																		
16	4	500	6.50	77																		
17	4	335	5.00	67	C. S. & G.	17	11	16	5	15.14	23	137	134	168			15	9			24	Local gauge, 8.6′.
17	5	650	10.00	a 65																		
18	6	530	7.25	a 73	C. S. & G.	17	11	15.6	4.5	14.24	26.8	135	125	162			23.25	.75			24	Local gauge, 8.05′. Velocity of current per second, 4′.
18	7	390	2.50	156																		
18	8	390	1.25	a 332																		
18	9	1,130	8.75	129																		
15	10	200	3.50	a 57																		
19	10	160	2.75	a 58	do	17	9	16	7	14	26.3	135	134	161			16		8		24	Local gauge, 7.65′.
19	11	650	13.25	49																		
20																						Eighty-six hours tied up to bank.
21																						
22																						
23																			10		10	
24																				24	24	
Total	11	6,435	78.25													9.50	78.25	9.75	18	24	139.5	
Average				82.3		17	10.8	15.8	5	14.49	24.5	135	129	163								
Per cent																6.8	56.1	7	12.9	17.2	100	

NOTE.—C. S. & G. = Coarse sand and gravel.

a Cuts made downstream

LOWER POINT PLEASANT (79.5 R).

On October 23 orders were sent by J. A. Ockerson, principal assistant engineer, for the *Beta* to move from Cherokee Crossing (89 R) to Lower Point Pleasant (79.5 R).

The *Beta* and plant arrived at 1.45 p. m. on October 24 and dredging began on the following day at 1 p. m. The reef on this bar showed a depth of only 7 feet when dredging began. The material was sand mixed with gravel and an occasional mud lump. Snags were also encountered. These and the mud lumps perhaps account for the persistency with which the reef maintained itself in this locality. The general conditions leading to the selection of this location for dredging will be described later.

Three obstructions were encountered on the first cut. The pieces of yellow pine which floated to the surface indicated the presence of a wreck. The cutters were raised and the dredge pulled ahead for a distance of about 40 feet, where they were again lowered to a depth of about 17 feet. In the next 3 cuts 6 obstructions were encountered which were supposed to be logs or parts of wrecks. In cuts Nos. 5 and 6 more snags were encountered, and the pumps were shut down to examine the cutter machinery after a continuous run of 49 hours. The bolts which held the journal box at the ends of the ladder pontoons were found to be pulled out. This allowed the bevel pinion to ride upon the other gear wheel and strip the cogs. The middle cutter on the starboard suction was found to be missing and the shaft was badly cut at the lower end. Attempts were made to recover this cutter, but it could not be located. A new cutter was put on and repairs were completed at 7.30 p. m., October 28, when dredging was resumed. No snags were encountered in cut No. 7.

Dredging was continued until October 30, when the ladder shafting broke and stripped the cogs from a bevel pinion. This was repaired, but broke again after a short run, and work was continued without the cutters.

Work was completed at this bar at 5 a. m. on Monday, October 31, after which two days were devoted to repairs, and the plant was then moved to Cherokee Crossing (89 R) to complete the dredging at that point.

All the time lost at Point Pleasant Bar was in repairs to cutter machinery. The total length of cuts made was 9,415 feet, and the time of actual dredging was 109½ hours. This gives an average rate of 86.2 feet per hour. The area covered by these cuts was about 200 feet wide and 1,820 feet long.

In computing the volume of material handled, an area located so as to cover the cuts symmetrically and 800 by 2,100 feet in size has been taken. This gives a total volume of material removed of 82,370 cubic yards, or an average of 754 cubic yards per hour. The cost of this work was $2,315.51, or an average of 2.8 cents per cubic yard.

The records of the depths of material removed from the cuts as shown by measurements taken ahead of the cutters and also behind them in the cuts of this bar and at Cherokee afterwards is quite complete. If these measurements be used, we can obtain another approximation to the volume of the material actually removed by the dredge. This does not take into account the vast amount of material which is known to be moving along the bed of the river, and assumes that the sides of the bed are practically stable and that the measurements in front of and behind the cutters give the actual depths of the material before and after dredging. Assuming side slopes of 1 on 3, and taking the cuts as 40 feet in width at the bottom, the total quantity removed would appear to be 128,953 cubic yards, which is fully 50 per cent greater than that obtained in the previous estimate.

Before dredging began the least depth on this reef was 7 feet and the distance between the 9-foot curves in the upper and lower pools was 800 feet. The dredging cuts were located along the extension of the lower pool. While the dredge was at work at this bar the river fell about 2 feet and then rose nearly 3 feet.

The following tables show the cost of the work and details of the operations at Lower Point Pleasant Crossing:

Dredge Beta.—Cost of work at Lower Point Pleasant, October 25 to November 3, 1898.

Labor	$1,171.05
Subsistence	241.12
Fuel	793.65
Engineer's supplies, miscellaneous	16.94
Engineer's supplies, oil	19.13
Mate's supplies	9.36
Repairs	47.32
Lighting supplies	9.09
Miscellaneous	2.59
Stationery and office supplies	.76
Laundry supplies	4.50
	2,315.51

Dredge Beta.—Summary of operations at Lower Point Pleasant, Mo. (79.5), October 25 to November 3, 1896.

Date.	Conditions of work.														Distribution of time.							Remarks.
	Cuts.					Average depth.				Heads.		Revolutions (average per minute.)		Steam pressure.								
	Number.	Length.	Time.	Rate per hour.	Material.	Suction.	A head of dredge.	In wake of dredge.	Material removed.	Suction.	Delivery.	Pumps.	Cutter engines.		Placing plant.	Dredging.	Repairs.	Making up tow.	Towing.	Sundays and holidays.	Total.	
1896.		Feet.	Hrs.	Feet.		Feet.	Feet.	Feet.	Feet.	Feet.	Feet.				Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	
Oct. 25	1	840	11	76	S. G. & M.	16.5	6.70	13.5	6.8	16.83	25.3	137	130	170	13	11					24	Local gauge 7 feet.
26	2	1,100	9.50	a113	...do	16.5	8	13.2	5.2	16.83	26.8	135	128	166		24					24	Velocity of current 3.3 feet per second. Local gauge 6.9 feet.
26	3	1,100	9.50	113																		
26	4	925	5	a185																		
27	5	850	10.50	81	...do	17	8	13.7	5.7	18.42	28.3	135	144	163		14	10				24	Local gauge 6.9 feet.
27	6	190	3.50	54																		
28	7	450	4.50	100	M. F. S	16	7	14	7	13.90	25.8	135	134	148		4.5	19.5				24	Do.
29	7	150	1.50	100	M. C. S.	16	7.25	13	5.8	13.22	25.6	136	130	159		24					24	Local gauge 7 feet.
29	8	650	7.50	a87																		
29	9	600	4.50	133																		
29	10	600	5.50	a109																		
29	11	400	5	80																		
30	11	230	2.25	102	...do	14	8	13	5	14.24	24.1	136.5	123	160		14.75	9.25				24	Without cutters in cut 13.
30	12	630	5.75	a110																		
30	13	250	6.75	37																		
31	13	450	17	26	F. S. & M.	14	9	14	5	13.33	23.2	139		168		17		7			24	Local gauge 6.9 feet.
Nov. 1																				24	24	Local gauge 7 feet.
2																			24		24	Local gauge 6.9 feet.
3																	24				24	
Total	13	9,415	109.25												13	109.25	62.75	7	24	24	240	
Average				86		16	7.70	13.5	5.8	15.25	25.6	136	131	162								
Per cent															5.4	45.5	26.2	2.9	10	10	100	

NOTE.—S. G. & M.=Sand, gravel, and mud; M. F. S.=Medium fine sand; M. C. S.=Medium coarse sand; F. S. & M.=Fine sand and mud.

a Cuts made downstream.

CHEROKEE CROSSING (89 R)—THIRD TIME.

The *Beta* and plant returned to Cherokee Crossing on November 2. Needed repairs to the cutter machinery were made on November 3 and 4, and dredging commenced at 2 p. m. on November 5 at the lower end of the reef along the line previously dredged by the *Beta*. The material was soft sand, with some gravel. Large quantities of this material were moving along the bottom, so that the progress of the dredge was very slow. At the upper end of the cuts a compact bed of gravel was encountered. Dredging was continued until 9 p. m. November 12, when the work was completed, making a continuous run of seven days and seven hours, or one hundred and seventy-five hours, without stopping the pumps.

The area covered by the dredge was 2,930 feet in length and from 50 to 175 feet in width. The total length of cuts is 8,980 feet, giving an average rate of 51.3 feet per hour.

The area used in computing the volume of material removed is 800 feet wide by 3,900 feet long. This gives a total of 128,148 cubic yards of material removed, or an average of 732 cubic yards per hour. The total cost of the above work was $3,008.93, or an average of 2.4 cents per cubic yard.

Using in this case, as described at Lower Point Pleasant Bar, the soundings in front of and behind the cutters, and taking the width of the cuts at the bottom as 40 feet and the side slopes as 1 on 3, we obtain the total volume removed of 101,105 cubic yards, or an average of 578 cubic yards per hour, a result about 20 per cent less than that obtained above.

The cost of the work at Cherokee Crossing, third time, and details of the operations are shown in the following tables:

Dredge Beta.—Cost of work at Cherokee Crossing, third time, November 4 to 13, 1896.

Labor	$1,465.47
Subsistence	244.83
Fuel	1,182.22
Engineer's supplies, miscellaneous	20.88
Engineer's supplies, oil	20.50
Mate's supplies	20.29
Repairs	36.91
Lighting supplies	9.71
Miscellaneous	2.66
Stationery and office supplies	.13
Laundry supplies	5.33
	3,008.93

Dredge Beta.—Summary of operations at Cherokee Crossing (89), November 4 to 13, 1896.

Date.	Conditions of work.														Distribution of time.						Remarks.
	Cuts.					Average depth.				Heads.		Revolutions (average per minute).									
	Number.	Length.	Time.	Rate per hour.	Material.	Suction.	Ahead of dredge.	In wake of dredge.	Material removed.	Suction.	Delivery.	Pumps.	Cutter engines.	Steam pressure.	Placing plant.	Dredging.	Repairs.	Making up tow.	Sundays and holidays.	Total.	
1896.		*Feet.*	*Hrs.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*				*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	
Nov. 4																	24			24	Local gauge 6 feet.
5	12	250	10	*a* 25	S. & G.	17	7.5	15	7.5	13.56	22	137	100	163	14	10				24	Local gauge 6.15 feet.
6	12	490	11	*a* 45	...do	17	8.5	15.5	7	13.84	22.9	137	101	162		24				24	
6	13	480	13	37																	
7	13	260	10	26	...do	17	10	14.5	4.5	14.05	26.8	138	124	167		24				24	
7	14	600	14	*a* 43																	
8	14	200	4.75	*a* 42	M. F. S.	17	10	15	5	13.34	24.5	136	111	166		24				24	
8	15	500	7.75	65																	
8	16	700	11.50	*a* 61																	
9	16	200	3	*a* 67	S. & G.	17	10.5	16.5	6	13.77	25.9	137	123	160		24				24	Local gauge 7.35 feet.
9	17	690	9	77																	
9	18	500	8.50	*a* 59																	
9	19	250	3.50	71																	
10	19	1,225	24	51	Compt. G.	17	12.5	16.5	4	13.49	27.5	137	126	164		24				24	Local gauge 7.65 feet. High southeast wind.
11	19	1,055	24	44	...do	18	12	17.5	5.5	13.06	30.8	139	1 18	165		24				24	Local gauge 7.8 feet. Velocity of current, 4.25 feet.
12	19	230	7	33	...do	18	11.5	17	5.5	14.12	27.4	136	105	166		21			8	24	Local gauge 7.65 feet.
12	20	600	7	*a* 86																	
12	21	750	7	*a*107																	
13																		24		24	Local gauge 7.45 feet.
Total	21	8,980	175												14	175	24	24	8	240	
Average				51.3		17.8	10.7	16.1	5.4	13.65	25.9	137	113	164							
Per cent															5.8	72.9	10	10	1.8	100	

NOTE—S. & G.=Sand and gravel; M. F. S.=Medium fine sand; Compt. G.=Compact gravel.

a Cuts made downstream.

CHEROKEE CROSSING (89 R)—FIRST TIME.

The dredge *Alpha* left Memphis (230 L) on the morning of August 30 for Cherokee Crossing (89 R), where she was to begin the season's work. Cherokee Crossing was reached at noon on September 4. A survey was made and floats were run to determine the direction of the flow. The least depth on the crossing was found to be 8 feet, with the river falling one-half foot per day. In attempting to locate the cut so as to interfere as little as practicable with steamboats, a line was selected considerably higher upstream than last season, and subsequent developments indicated that this was a mistake. The head piles were placed on September 5, and on September 7 dredging began in material composed of medium coarse sand.

The condition of the bushings in the main pump was overlooked in the general repairs made prior to beginning work, owing to the great amount of labor involved in getting at them. When work began, however, an average of three hours per day was found necessary for repairs, most of the same being on the main pump. On September 16 the runner on the main pump broke and 4¼ days were lost thereby. The pump runner which had been previously repaired was put in place and the bushings, which were entirely worn out, were renewed from material made from a broken pile. At the time of the breakdown 2,355 linear feet of cut had been made in water about 7 feet deep, with the cutters lowered to a depth of 12 feet.

Dredging was resumed at midnight on September 20 at cut No. 3. This cut had partially filled while the repairs were being made, as the dredge had not been moved out of the channel. This failure to move the plant out of the channel when not at work was directly contrary to my general instructions, and, as soon as I learned of it, positive orders were issued that in all cases where work was suspended the dredges and all plant belonging thereto must be moved out of the channel.

Dredging was continued until 12 p. m. on September 26 without stopping except when changing cuts. This shows a continuous run of 144 hours, with the exception of 3¼ hours used in changing from one cut to the other. Work at this point was finished on September 28 and the plant moved to Upper Point Pleasant (79 R).

Six parallel cuts were made, aggregating 4,610 feet in length. The actual dredging time was 295 hours, or an average rate of 15.6 feet per hour. The cuts covered an area of about 1,200 feet long and 200 feet wide in the widest part.

Computing the volume as before explained, we have in this case to consider an area 1,875 by 800 feet. This would give a total of 50,111 cubic yards of material removed, or an average of 170 cubic yards per hour. The total cost was $3,309.51 and the average cost per cubic yard was 6.6 cents.

The coal consumed by the dredge while running continuously amounted to 12 bushels of Pittsburg lump coal per hour.

During the time the dredge was at work the river first fell steadily for 10 days, the fall amounting to 5 feet; it was then stationary for about 5 days, after which there was a rise of about 2 feet.

The following tables give the cost and details of the operations at Cherokee Crossing (first time):

Dredge Alpha.—Cost of work at Cherokee Crossing, September 5 to 28, 1896.

Labor	$2,161.50
Subsistence	541.52
Fuel	476.50
Engineer's supplies, miscellaneous	15.72
Engineer's supplies, oil	33.23
Mate's supplies	13.89
Repairs	30.36
Lighting supplies	16.72
Miscellaneous	5.38
Stationery and office supplies	.87
Laundry supplies	13.82
	3,309.51

Dredge Alpha.—Summary of operations at Cherokee Crossing (89), September 5 to 28, 1896.

[Length of discharge pipe, 1,087 feet.]

Date.	Conditions of work.														Distribution of time.								Remarks.
	Cuts.					Average depth.				Heads.		Revolutions (average per minute).		Steam pressure.									
	Number.	Length.	Time.	Rate per hour.	Material.	Suction.	Ahead of dredge.	Astern of dredge.	Material removed.	Suction.	Delivery.	Main pump.	Jet pump engine.a		Placing plant.	Dredging.	Changing cuts.	Repairs.	Making up tow.	Towing.	Sundays and holidays.	Total.	
1896.		*Feet.*	*Hrs.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*				*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	
Sept. 5	....	......	......	.....	....	.....	......	......	......	......	......	......	......	.....	24	......	.....	......	......	......	.....	24	
6	....	......	......	.....	....	.....	......	......	......	......	......	......	......	.....	.....	......	.....	......	......	......	24	24	
7	1	190	11.50	16.5	S	12	8.3	(b)	......	5.20	(b)	124	......	137	8	11.50	.....	4.50	......	......	.....	24	
8	1	290	19.50	14.8	S. & G ..	12	7.1	(b)	......	5.20	(b)	126	......	136	.....	19.50	.....	4.50	......	......	.....	24	
9	1	305	21.75	14.1	C. S.....	12	7.6	(b)	......	5.42	(b)	125	......	137	.....	21.75	.....	2.25	......	......	.....	24	
10	1	60	20.75	14.5	C. S.....	12	7.8	(b)	......	5.53	(b)	126	......	139	.....	20.75	2	1.25	......	......	.....	24	
10	2	240																					
11	2	440	19.75	22.3	S. & G ..	12	7.8	(b)	......	5.65	......	128	......	141	.....	19.75	.....	4.25	......	......	.....	24	
12	2	120	6.50	18.4	S. & G ..	12	8.1	(b)	......	5.20	16.17	120	......	139	.....	6.50	.....	11.50	......	......	6	24	
13	2	60	6	10	S	12	7	(b)	......	5.08	16.86	122	......	137	.....	6	.....	......	......	......	18	24	
14	2	350	21	17	S. & G ..	12	7.7	(b)	......	5.53	19.40	124	......	141	.....	21	3	......	......	......	.....	24	
15	3	230	21.75	10.6	S	12	6.9	(b)	......	5.08	20.10	125	......	137	.....	21.75	2.25	......	......	......	.....	24	
16	3	70	5.25	13	S	12	7.8	(b)	......	4.86	15.70	113	......	135	.....	5.25	.....	18.75	......	......	.....	24	Runner of main pump broke and replaced by another.
17	....	......	......	.....	....	.....	......	......	......	......	......	......	......	.....	.....	......	.....	24	......	......	.....	24	
18	....	......	......	.....	....	.....	......	......	......	......	......	......	......	.....	.....	......	.....	24	......	......	.....	24	
19	....	......	......	.....	....	.....	......	......	......	......	......	......	......	.....	.....	......	.....	24	......	......	.....	24	
20	....	......	......	.....	....	.....	......	......	......	......	......	......	......	.....	.....	......	.....	24	......	......	.....	24	
21	4	205	23.25	8.8	S	12	6.9	11.8	4.9	4.75	18.02	122	......	140	.....	23.25	.75	......	......	......	.....	24	
22	4	290	24	12	S. & G ..	12	6.7	10.3	8.6	5.08	19.17	124	......	140	.....	24	.....	......	......	......	.....	24	
23	4	285	21.75	15.6	S. & G ..	12	7.6	10.8	3.2	4.97	16.86	124	......	140	.....	21.75	2.25	......	......	......	.....	24	
23	5	55																					
24	5	455	24	19	C. S.....	12	8.6	11.9	3.3	5.08	15.24	123	......	138	.....	24	.....	......	......	......	.....	24	
25	5	265	23.25	18.7	C. S.....	12	8.5	11.1	2.6	5.08	13.63	123	......	138	.....	23.25	.75	......	......	......	.....	24	
25	6	170																					
26	6	530	24	22	C. S.....	12	8.1	10.1	2	4.97	13.86	122	......	139	.....	24	.....	......	......	......	.....	24	
27	....	......	......	.....	....	.....	......	......	......	......	......	......	......	.....	.....	......	.....	......	24	......	.....	24	
28	....	......	......	.....	....	.....	......	......	......	......	......	......	......	.....	.....	......	.....	......	......	8	16	24	
Total	6	4,610	294	.....	....	.....	......	......	......	......	......	......	......	.....	32	294	11	143	24	8	64	570	
Average	....	......	......	15.7	....	12	7.8	10.9	8	5.16	16.82	124	......	138	.....	......	.....	......	......	......	.....	......	
Per cent	....	......	......	.....	....	.....	......	......	......	......	......	......	......	.....	5.5	51	2	25	4	1.5	11	100	

UPPER POINT PLEASANT (79 B).

The *Alpha* and dredging plant arrived at Point Pleasant on September 29, and dredging began at 5.15 p. m. on that date. The crossing was sounded and it was decided to open a channel parallel to the right bank and about 150 feet distant from it, in about the same position as the channel opened during the season of 1895. This channel, if opened, would follow the shore, and would practically eliminate two bad crossings. The material was medium fine sand.

The dredging continued until 6 p. m. on Saturday, October 3, when the dredge was moved out of the cut and work was suspended over Sunday. Dredging was resumed at 6 p. m. on October 5 and continued until 6 p. m. on the following day, when it was found that the bushings of the main pump were so badly worn as to need immediate repairs. The pumps were therefore stopped, the dredge was moved out of the channel, and the work of repairing begun. Two new bushings were turned and put in place on the hub and shaft of the main pump. The hub on the aft head was taken out and turned down to fit the new bushings, and new steel keys were made and fitted in the coupling and shaft. This work was completed on October 8, and dredging was resumed at midnight of that day.

On October 15, 1896, I visited the *Alpha* and found the water rising very rapidly. With her suction lowered to its extreme limit the amount of material removed from the bottom did not much exceed 1 foot. Under the circumstances the dredging work seemed of little practical advantage. I did not issue orders for a suspension of the dredging, however, until my return to St. Louis. These orders were received on October 19, and the dredging plant was tied up to the bank. When the orders were received the river had already fallen some 3¼ feet below the crest of the rise, but practically no evidence remained of the work already done.

The work at this bar can not be considered to have been completed, and subsequent alterations in the river channel, induced by the rise above referred to, rendered it unnecessary to attempt further operations at this point.

The cuts made aggregated 6,370 feet in length, and the time of actual dredging was 306¾ hours. This gives an average rate of 20.8 feet per hour.

The volume of material removed, computed from an area 500 feet in width by 2,800 feet in length, gives a volume of 28,602 cubic yards, making the average number of cubic yards moved per hour 93.2, and the average cost per cubic yard 10.4 cents.

On the afternoon of October 22 the steamer *Sheffield* grounded and collided with the floating pipe. Considerable damage was done to the pipe and couplings and to the wheel of the steamer. On the following day she was pulled off by the steamer *Mississippi*.

The cost of this work and other details of the operations will be found in the following tables:

Dredge Alpha.—Cost of work at Upper Point Pleasant, September 29 to October 23, 1896.

Labor	$2,191.82
Subsistence	468.80
Fuel	594.83
Engineer's supplies, miscellaneous	13.40
Engineer's supplies, oil	31.54
Mate's supplies	6.31
Repairs	120.17
Lighting supplies	12.72
Miscellaneous	4.41
Stationery and office supplies	.19
Laundry supplies	11.97
	3,456.16

Dredge Alpha.—Summary of operations at Upper Point Pleasant (79), September 29 to October 23, 1896.

Date.	Conditions of work.														Distribution of time.							Length of discharge pipe.	Remarks.
	Cuts.					Average depth.				Heads.		Revolutions (average per minute).											
	Number.	Length.	Time.	Rate per hour.	Material.	Suction.	Ahead of dredge.	Astern of dredge.	Material removed.	Suction.	Delivery.	Main pump.	Jet pump engine.b	Steam pressure.	Placing plant.	Dredging.	Changing cuts.	Repairs.	Towing.	Sundays and holidays.	Total.		
1896.		*Feet.*	*Hrs.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*				*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Feet.*	
Sept. 29....	1	55	6.75	8.2	Sand and clay.	12	8.5	11	2.5	4.97	18.25	117	......	135	8.25	6.75	.....	.....	9	.....	24	1,037	Local gauge, 7.8 feet; set to read the same as New Madrid gauge.
30....	1	490	24	20.4	Sand....	12	7.8	10.6	2.8	5.08	22.40	120	......	140	......	24	.....	.....	.....	.....	24		
Oct. 1....	1	285	24	11.8	Sand....	12	6.4	11.2	4.8	5.08	23.10	123	......	138	......	24	.....	.....	.....	.....	24		
2....	1	320	24	13.3	Sand....	12	6.7	10.4	3.7	5.08	25.18	125	......	140	......	24	.....	.....	.....	.....	24		
3....	1	195	18	11	Sand....	12	6.8	10	3.2	5.08	22.87	123	......	143	......	18	.....	.....	.....	6	24		
4....	1	50	6	8.3	Sand....	12	7.2	9.5	2.3	5.08	20.79	115	......	141	......	6	.....	.....	.....	18	24		Local gauge, 7.1 feet.
5....	1	155	18	8.6	Sand....	12	6.4	9.5	3.1	4.75	22.17	118	......	142	......	18	.....	6	.....	.....	24		
6....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	......	.....	......	.....	.....	24	.....	.....	24	....	Main pump runner removed, repaired, and replaced with new bushings and keys.
7....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	......	.....	......	.....	.....	24	.....	.....	24		
8....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	......	.....	......	.....	.....	24	.....	.....	24		
9....	1	475	24	19.8	(*a*)	12 13.5	9	10.9	1.9	4.86	23.10	120	......	139	......	24	.....	.....	.....	.....	24		Local gauge, 8.9 feet.
10....	1	110	11	18.2	(*a*)	13	10.9	11.9	1	5.53	20.58	120	......	138	2	11	5	.....	.....	6	24	498	Local gauge, 9.7 feet.
10....	2	90				12																	
11....	2	440	6	73.3	(*a*)	13.5	10.9	12.7	1.8	6.89	20.83	126	......	144	......	6	.....	.....	.....	18	24		Local gauge, 10.8 feet.
12....	2	935	22	42.5	(*a*)	13.5	10.5	12.8	2.3	7.23	19.63	121	......	145	......	22	2	.....	.....	.....	24		Local gauge, 11.4 feet.
13....	2	110	22	32.7	(*a*)	13.5	10.8	12.5	1.7	6.89	19.17	123	......	142	......	22	2	.....	.....	.....	24		Local gauge, 11.5 feet.
13....	3	610																					
14....	3	755	23	32.8	(*a*)	13.5	10.8	12.6	1.8	7.34	18.94	124	......	143	1	23	.....	.....	.....	.....	24		Local gauge, 11.2 feet.
15....	3	45	17.25	24.3	(*a*)	13.5	10.5	12.6	2.1	7.34	17.09	122	......	141	......	17.25	6.75	.....	.....	.....	24		Local gauge, 10.8 feet.
15....	4	375																					
16....	4	305	24	12.7	(*a*)	13.5	8.2	11.7	3.5	8.13	14.82	118	......	144	......	24	.....	.....	.....	.....	24		Local gauge, 10.2 feet.
17....	4	190	15.75	12.1	(*a*)	13.5	7.4	10.3	2.9	7.91	15.24	117	......	141	2	15.75	.....	1.25	.....	5	24		Local gauge, 9.6 feet.
18....	4	170	6	28.3	(*a*)	12	8.1	10	1.9	7.68	13.86	117	......	142	1	6	.....	.....	.....	17	24		Local gauge, 9 feet.
19....	4	210	15	14	(*a*)	12	7.5	10.2	2.7	8.02	14.55	118	......	142	......	......	.....	.....	.....	.....	15		Local gauge, 8.7 feet.
20–23.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	......	.....	......	.....	.....	.....	.....	.....	.....	......	105 hours tied up to bank.
Total....	4	6,370	306.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	......	.....	14.25	306.75	15.75	79.25	9	70	495		
Average.	.....	.....	.....	20.8	.....	13	9.3	11.7	2.4	6.27	19.5	118	......	141	.....	.....	.....	.....	.....	.....	.....		
Per cent.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	......	.....	2.8	62	3.2	16	2	14	100		

Total quantity dredged, 28,601.7 cubic yards; average per hour, 93.2 cubic yards.

a No record.

b Water jet.

COMPROMISE BAR (77 L).

On October 23 the *Alpha* was ordered by J. A. Ockerson, principal assistant engineer, to Compromise Bar. The plant was taken in tow the following day and arrived at its destination in the afternoon. A survey was made and two head piles were set. Dredging began at 6 p. m. on October 25. The material was found to be coarse sand and gravel. The depth of the suction was 12 feet. The steamer *Mississippi* was required for the Commission trip and the *Fred. Hartweg* was chartered for use as tender during her absence.

Cut No. 1, 910 feet long, was completed at 3 a. m. October 28, and the dredge moved to the lower end of cut No. 2. It was then discovered that the pump shaft was out of line. The runner was removed and it was found that the hub in the after head, the shaft, and the bushings were badly worn, although thorough lubrication was effected by compression grease cups. An extra runner and shaft had been repaired in St. Louis, and phosphor bronze bushings had also been secured. These were put in place, and after a delay of three and three-fourth days dredging was resumed on November 1 at 7 a. m.

Dredging was continued without further interruption from repairs until midnight November 10, when work at this bar was completed. With the water about 4 feet above the lowest stage of the season, there was found to be a 12-foot channel 400 feet wide.

By this time the stage of the river was so high that no difficult crossings were reported between Cairo and Memphis. The plant was therefore moved to the bank awaiting further developments.

The work at this bar consisted of 7 cuts aggregating 5,405 feet in length. The actual dredging time was 257¾ hours and the average rate was 21 linear feet per hour.

The volume of material removed, computed from an area 800 feet wide and 1,600 long, is 80,555 cubic yards, or 312¼ cubic yards per hour. The total cost was $3,473.68, and the average cost per cubic yard is 4.3 cents.

The cost of this work and details of the operations are given in the following tables:

Dredge Alpha.—Cost of work at Compromise Bar, October 25 to November 15, 1896.

Labor	$2,012.95
Subsistence	422.82
Fuel	674.03
Engineer's supplies, miscellaneous	7.29
Engineer's supplies, oil	37.82
Mate's supplies	7.06
Repairs	278.99
Lighting supplies	16.52
Miscellaneous	1.89
Stationery and office supplies	.69
Freight	.50
Laundry supplies	13.12
	3,473.68

Dredge Alpha.—Summary of operations at Compromise Bar (77), October 24 to November 15, 1896.

[Length of discharge pipe, 1,037 feet.]

Date.	Conditions of work.														Distribution of time.								Remarks.
	Cuts.					Average depth.				Heads.		Revolutions (average per minute).		Steam pressure.									
	Number.	Length.	Time.	Rate per hour.	Material.	Suction.	Ahead of dredge.	Astern of dredge.	Material removed.	Suction.	Delivery.	Main pump.	Jet pump engine.*b*		Placing plant.	Dredging.	Changing cuts.	Repairs.	Making up tow.	Towing.	Sundays and holidays.	Total.	
1896.		*Feet.*	*Hrs.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*				*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	
Oct. 24																			13.50	10.50		24	Local gauge 7 feet; set to read the same as New Madrid gauge.
25	1	70	6	11.7	S. & G.	12	10	11.8	1.8	5.87	18.48	120		139	13.50	6					4.50	24	
26	1	420	23.50	18	S. & G.	12	8.7	11.2	2.5	6	20.10	120		144		23.50		0.50				24	
27	1	375	22.50	17	S. & G.	12	8.7	10.2	1.8	6	20.33	121		140		22.50		1.50				24	
28	1	45	3	15	S. & G.	12	9.8	11.2	1.4	6.21	20.79	120		139		3	2	19				24	Local gauge 7.1 feet.
29																		24				24	Main pump runner removed and replaced by another with new bushings, keys, etc.
30																		24				24	
31																		24				24	
Nov. 1	2	265	17	15.6	S. & G.	12	8.9	12.5	3.6	5.42	20.33	115		139		17					7	24	
2	2	260	24	10.4	S. & G.	12	8.5	10.7	2.2	5.42	18.48	117		138		24						24	
3	2	175	23	14.8	(*a*)	12	9.4	10.9	1.5	5.65	18.94	118		138		23	1					24	Local gauge 7 feet.
3	3	165																					
4	3	435	24	18.1	(*a*)	12	9.2	10.8	1.6	5.20	19.17	118		138		24						24	Local gauge 7.2 feet.
5	3	230	21.75	21.9	(*a*)	12	10	11.7	1.7	5.31	19.86	117		138		21.75	2.25					24	Local gauge 7.4 feet.
5	4	245				13																	
6	4	360	24	15	(*a*)	13	9.8	11.6	1.8	6.66	20.10	118		138		24						24	Local gauge 7.6 feet.
7	4	135	17	26.2	(*a*)	13	10.3	11.8	1.5	6.10	23.79	128		138		17	1				6	24	Local gauge 7.8 feet.
7	5	310																					
8	5	215	6	35.8	(*a*)	13.50	10.7	12.2	1.5	5.76	19.17	127		145		6					18	24	Local gauge 8.1 feet.
9	5	255	22	47	(*a*)	13.50	11	12.8	1.3	5.87	24.02	129		141		22	2					24	Local gauge 8.4 feet.
9	6	750																					
9	7	30																					
10	7	665	24	27.7	(*a*)	13.50	11	12.2	1.2	6	21.94	126		139		24						24	Local gauge 8.7 feet.
11																			24			24	Local gauge 8.8 feet.
12–14																							72 hours tied up to bank.
15																					24	24	
Total	7	5,405	257.75												13.50	257.75	8.25	93	37.50	10.50	59.50	480	
Average				21		12.7	9.9	11.6	1.7	5.82	20.40	120		139									
Per cent															2.8	53.7	1.7	19.4	7.8	2.2	12.4	100	

MOVING TO WINTER QUARTERS.

The *Alpha* was moved to about a mile above New Madrid, Mo. (71 R), on November 16, and remained there until December 1, when orders were received to discharge all employees not needed for care of plant and repairs.

On November 13, after finishing work at Cherokee, the *Beta* was tied up to the bank, awaiting orders. Minor repairs were made until December 1, when orders were received to disband the force not needed for care and repair of plant and to move the entire dredging plant to East Cairo, Ky.

The work of towing to winter quarters was begun at once, and the dredging plants of both dredges were moored at East Cairo on December 12. The steamer *Mississippi*, having returned from the Commission trip, assisted in towing the plant up.

The following tables give the cost of preparing the plant for work prior to September 1, 1896, cost of awaiting developments in stage of river and moving fleet to winter quarters, and other details of the dredging operations:

Dredge Beta.—Cost of testing and moving from winter quarters, August 19 to 31, 1896.

Labor	$979.73
Subsistence	372.16
Fuel	217.80
Engineer's supplies, miscellaneous	28.07
Engineer's supplies, oil	15.18
Mate's supplies	15.69
Repairs	64.03
Lighting supplies	9.10
Miscellaneous	2.22
Stationery and office supplies	1.19
Freight	.60
Laundry supplies	5.79
Total	1,711.56

Dredge Alpha.—Minor repairs and preparations for field operations prior to September 1, 1896.

Labor	$1,417.41
Subsistence	258.11
Fuel	210.08
Engineer's supplies, miscellaneous	7.18
Mate's supplies	1.05
Repairs	15.62
Lighting supplies	3.63
Laundry supplies	5.43
Towing	24.50
Total	1,943.01

Dredge Beta—Cost of waiting for developments in stage of river and moving to winter quarters, October 20 to 23 and November 14 to December 15, 1896.

Labor	$4,750.79
Subsistence	767.00
Fuel	776.08
Engineer's supplies, miscellaneous	36.83
Engineer's supplies, oil	22.89
Mate's supplies	12.64
Repairs	66.40
Lighting supplies	28.56
Miscellaneous	5.07
Stationery and office supplies	1.43
Freight	4.34
Laundry supplies	17.30
Total	6,489.33

Dredge Alpha.—Cost of waiting for developments in stage of river and moving to wi quarters, November 16 to December 21, 1896.

Labor	$2,063.
Subsistence	459.
Fuel	258.
Engineer's supplies, miscellaneous	4.
Engineer's supplies, oil	3.
Mate's supplies	.
Repairs	4.
Lighting supplies	8.
Laundry supplies	6.
Total	2,809.

Dredges Alpha and Beta.—Cost of preparing fleet for work, returning same to wi quarters, and expenses while tied up awaiting low water.

Labor	$9,211.
Subsistence	1,856.
Fuel	1,462.
Engineer's supplies, miscellaneous	76.
Engineer's supplies, oil	41.
Mate's supplies	29.
Repairs	150.
Lighting supplies	50.
Miscellaneous	7.
Stationery and office supplies	2.
Freight	4.
Laundry supplies	34.
Towing	24.
Total	12,953.

Dredges Alpha and Beta.—Cost of actual dredging, during low water season 1896.

Labor	$16,237.
Subsistence	3,386.
Fuel	8,051.
Engineer's supplies, miscellaneous	176.
Engineer's supplies, oil	242.
Mate's supplies	94.
Repairs	855.
Lighting supplies	114.
Miscellaneous	30.
Stationery and office supplies	6.
Freight	2.
Laundry supplies	73.
Total	29,272.

The total cost during the season, including cost of preparing plant for work, mo ing to the field, waiting for lower stage of river, and moving to winter quarters, f dredges *Alpha* and *Beta*, is therefore $42,226.17.

ng operations, Mississippi River between Cairo and Memphis, during low-water season of 1896.

	Name of dredge.	Cuts.				Average depth.				Heads.	
		Number.	Total length.	Time required.	Rate per hour.	Suction.	Ahead of dredge.	Astern of dredge.	Material removed.	Suction.	Delivery.
			Feet.	*Hours.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Aug.	Beta....	10	5,945	121.0	49.1	15.3	9.2	13.4	4.2	14.4	19.1
Sept.	Beta....	3	2,265	66.0	34.3	15.6	9.5	13.5	4.0	15.2	21.6
R), 96.	Beta....	9	5,660	63.7	89.0	15.0	9.4	13.5	4.1	15.2	20.8
Cross- to 15,	Beta....	16	12,175	87.0	140.0	20.5	14.8	18.7	3.8	15.0	23.4
9 R), to 24,	Beta....	11	6,435	78.2	82.3	17.0	10.8	15,8	5.0	14.5	24.5
,Mo., Nov.	Beta....	13	9,415	109.2	86.2	16.0	7.7	13.5	5.8	15.2	25.6
9 R), to 13,	Beta....	10	8,980	175.0	51.3	17.3	10.7	16.1	5.4	13.6	25.9
9 R), o 28,	Alpha ..	6	4,610	294.0	15.7	12.0	7.8	10.9	3.0	5.2	16.8
t, Mo. Oct.	Alpha ..	4	6,370	306.7	20.8	13.0	9.3	11.7	2.4	6.8	19.5
7 L), 896.	Alpha ..	7	5,405	257.7	21.0	12 7	9.9	11.6	1.7	5.8	20.4

	Name of dredge.	Revolutions (average per minute).		Steam pressure (pounds per square inch).	Distribution of time.								
		Pumps.	Cutter engines.		Placing plant.	Dredging.	Changing cuts.	Repairs.	Passing boats.	Making up tow.	Towing.	Sundays and holidays.	Total time.
					Hrs.	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*
Aug.	Beta ..	129	120	161	53.5	121.0	25.2	12.7	1.0	39.0	104.0	19.0	375.5
R),	Beta ..	134	125	165	16.5	66.0	5.0	14.5	.....	6.5	25.5	.....	134.0
R), 896.	Beta ..	135	119	167	11.0	63.7	7.7	6.5	.....	20.5	97.5	10.0	217.0
ross- o 15,	Beta ..	134	132	160	23.0	87.0	.....	.....	.....	5.5	28.0	.....	143.5
9 R), 15 to	Beta ..	135	129	163	9.5	78.2	.....	9.7	.....	18.0	24.0	.....	139.5
ant, 25 to	Beta ..	136	131	162	13.0	109.2	.....	62.7	.....	7.0	24.0	24.0	240.0
9 R), o 13,	Beta ..	137	113	164	14.0	175.0	.....	24.0	.....	24.0	.....	3.0	240.0
9 R), o 28,	Alpha	124	(*a*)	138	32.0	294.0	11.0	143.0	.....	24.0	8.0	64.0	576.0
ant, 29 to	Alpha	118	(*a*)	141	14.2	306.7	15.7	79.2	.....	.....	9.0	70.0	495.0
L), 896.	Alpha	120	(*a*)	139	13.5	257.7	8.25	93.0	.....	37.5	10.5	59.5	480.0

a Water jet.

Summary of dredging operations, Mississippi River between Cairo and Memphis, during lo water season of 1896—Continued.

Place and date.	Name of dredge.	Material moved.			Total cost.	Remarks.
		Dimensions of superficial area.	Cubic yards.	Cost per cubic yard.		
		Feet.		*Cents.*		
Island No. 40 (211 L), Aug. 31 to Sept. 24, 1896.	Beta	800 by 2,000	176,870	3.5	$6,122.51	Capsizing of pipes d layed the work 224½ hr
Island No. 34 (179 R), Sept. 25 to 30, 1896.	Beta	800 by 2.200	91,852	2.0	1,793.42	
Osceola Bar (164.5 R), Sept. 30 to Oct. 9, 1896.	Beta	800 by 2.300	65,555	3.6	2,379.05	
Hathaways Lower Crossing (102 L), Oct. 9 to 15, 1896.	Beta	800 by 2,400	80,592	2.0	1,671.59	
Cherokee Crossing (89 R), second time, Oct. 15 to 24, 1896.	Beta	800 by 2,500	62,000	2.8	1,742.58	
Lower Point Pleasant, Mo. (79.5 R), Oct. 25 to Nov. 3, 1896.	Beta	800 by 2,100	82,370	2.8	2,315.51	
Cherokee Crossing (89 R), third time, Nov. 4 to 13, 1896.	Beta	800 by 3,900	128,148	2.4	3,008.93	
Cherokee Crossing (89 R), first time, Sept. 5 to 28, 1896.	Alpha ..	800 by 1,875	50,111	6.6	3,309.51	114½ hours. *a*
Upper Point Pleasant, Mo. (79 R), Sept. 29 to Oct. 23, 1896.	Alpha ..	500 by 2,800	28,602	12.1	3,456.16	78 hours. *a*
Compromise Bar (77 L), Oct. 24 to Nov. 15, 1896.	Alpha ..	800 by 1,600	80,555	4.3	3,473.68	91 hours. *a*

a Repairs due to breaking of runner of main pump.

RESULTS OF THE SEASON'S WORK.

In order to make clear the results of the work, plats of the surveys made at th bars during the season have been prepared, the depths of water being indicated b contours and shaded areas, after reducing the soundings to the lowest gauge readin of the season. These surveys are given in the accompanying plates, numbers 1 to Plate 10 is a hydrograph showing the fluctuations of the gauges at New Madrid Fulton, and Memphis during the low-water season. A careful study has been mad of the entire subject, and below will be found a description of the various plate with the conclusions arrived at from examination of the same.

PLATE NO. 1, POINT PLEASANT AND VICINITY.

This shows the general condition of the river in the vicinity of Point Pleasan before dredging was begun by either the *Alpha* or the *Beta*. This stretch of th river is generally the worst between Cairo and the Head of the Passes. It will b noted that there are two channels coming up from below, which unite just abov the point marked C on the plate, and shortly afterwards again divide, one follow ing the right bank near Toneys Towhead, and the other the left bank. The *Alpha* first work at Point Pleasant, which was never completed on account of the hig water, was along the right bank in the vicinity of the point marked B on this plate known as Upper Point Pleasant Bar. The work last done by the *Alpha* was at th point A on the plate, this locality being known as Compromise Bar. The *Bet* worked at the point marked C on the plate, this point being known as Lower Poin Pleasant Bar. The locations C and A were selected by J. A. Ockerson, principa assistant engineer, from an examination of the ground in person, after the *Alph* had stopped work at the point B. The plate indicates very clearly the enormou amount of dredging work that would have been necessary to open a channel alon the right bank.

PLATE NO. 2, COMPROMISE BAR (77 L).

This shows the state of affairs at Compromise Bar (77 L), October 24, 1896, one da before dredging by the *Alpha;* November 8, 1896, during dredging by the *Alpha* November 11, 1896, one day after dredging by the *Alpha;* and December 3, 1896 twenty-three days after dredging by the *Alpha*. The location of the dredge cuts is indicated in outline on all the charts.

When dredging began at Compromise Bar, there was a practicable channel 7 feet in depth at a stage about 1 foot above the lowest water of the season. In fig. 1 it will be noted that the 9-foot curves of the upper and lower pools are about 600 feet apart. From an examination of the plat it would appear that the dredge cuts should have been located higher up in order to join these pools on the shortest line. Such a cut, however, would be almost square across the current, whereas the one selected was practically parallel to the direction of the flow, easier for boats to run and was along the shortest line between the 8-foot curves of the upper and lower pools.

Fig. 2 shows the conditions about two weeks later, while the dredging was in progress. Great changes due to natural causes have occurred, and we now find a 9-foot channel 1,400 feet wide with two openings over 11 feet in depth around the middle bar. At the time of this survey the dredge channel was not completed, but from the indications of the plat it would appear that deeper water already existed in the channel above than is found along the line of the dredge cuts. The material here moved by natural causes is far in excess of the capacity of any dredge. The stage of the river during this time changed but little for about twelve days, then it rose a foot in the next four days. While this rapid erosion was going on, the channel down the right bank, indicated on plate 1, had filled up.

On fig. 3 is shown the state of affairs just after dredging was completed. The upper channel, indicated on fig. 2, is closed up and, everything considered, the best channel would appear to lie along the line of dredging. Taken as a whole, there has been quite a large fill over the entire surface of the bar.

Fig. 4 shows the state of affairs twenty-three days after the dredging. The channel opened by the *Alpha* has been materially encroached upon, but is still visible and is apparently the best one available for steamboats. There is a practicable channel 7½ feet in depth, which is a foot deeper than existed before dredging. Fig. 4 indicates that the location selected for the dredging was the correct one. This last survey was made during a rapid rise in the river amounting to as much as 3 feet per day.

The results of the work at this bar are in my opinion satisfactory, the depth of the water worked in and the available depth to which the *Alpha* can excavate being considered.

PLATE NO. 3, UPPER POINT PLEASANT BAR (79 R).

The three figures show the condition October 1, 1896, before dredging by the *Alpha*; October 20, 1896, one day after dredging; and December 3, 1896, 45 days after dredging. This work, as already stated, was stopped before completion on account of a rise in the river rendering work by the *Alpha* of little value. It was subsequently entirely abandoned in order to open the other route already described in connection with plate 1.

Before dredging, fig. 1, there was a 7-foot channel extending up from the lower pocket some 1,800 feet, and the upper pocket extended down for the same distance. But for a distance of over 1,500 feet the best water did not exceed 6 feet in depth and in some places was only 5.2 feet. In the axis of the cuts as laid down the depth is less than 5 feet for a distance of 800 feet. The 9-foot curves are 2,300 feet apart and the lower 9-foot pool is separated from deep water below it for a distance of 200 feet by a bar on which the depth is less than 8 feet. The reef crowds close into the shore near the lower end of the proposed channel. It comes in toward the shore at an angle of about 30 degrees, and as the water on it is quite shallow, it forms an admirable natural jetty which effectually confines the upper pool and should, if the jetty theory is correct, produce a good channel along the shore. Deep water at the lower end may be due to this jetty effect.

Figure 2 shows the result after dredging was stopped. The rise which occurred, reaching a stage of about 6½ feet above the lowest water of the season, has practically obliterated all traces of the cuts.

In figure 3, 45 days after dredging, however, the conditions have somewhat improved, but the best practicable channel along the axis of the dredging would have a minimum depth of less than 6 feet.

No beneficial effects can be claimed for the work at this point, which, as before explained, was abandoned before completion.

PLATE NO. 4, LOWER POINT PLEASANT BAR (79.5 R).

The four figures on this plate show the condition October 24, 1896, 1 day before dredging; November 2, 1896, 2 days after dredging; November 17, 1896, 17 days after dredging; and December 3, 1896, 33 days after dredging; the location of the dredge cuts in all cases being indicated by the broken outline.

Before dredging began, as shown on figure 1, the least depth on the reef was 7 feet and the distance between the 9-foot curves of the upper and lower pools was 800 feet.

Figure 2 indicates a clear 9-foot channel over 200 feet wide in the narrowest pla and the 11-foot curve of the lower pool extending within 200 feet of the 11-foot cu of the upper pool; the good effect of the dredging is here very apparent.

Figure 3 indicates a straight channel 125 feet wide, with over 11 feet of wa clear across the reef. The channel is somewhat narrower than before, and the 9-f curve below the cuts shows a tendency to elongate and open another channel. T upper reef is also crowding down into the cut and threatens to obliterate it. T has narrowed the cut and is probably the cause of the deepening. This chan shows a deepening of over 4 feet when compared with the conditions shown figure 1.

Figure 4 shows the condition more than a month after the dredging was complet At the time this survey was made the river was rising very rapidly, reaching a sta of 13 feet above the lowest stage of the season. The original dredge cut has n been closed by the upper reef. In places the fill exceeds 8 feet in depth. Anot channel has been opened, the axis of which lies about 600 feet below the axis of cuts. It shows a depth of over 9 feet. This is doubtless a development of the 9-f pool shown on figure 3.

These enormous changes, due wholly to natural causes, indicate the difficulties with in attempting to determine the volume of material removed in the dredging means of measurements made before and after the work is done. In fact, the pr abilities are that such measurements usually give results too small rather than large.

Considering everything, I believe the channel at this point was well selected the work of dredging might have proved beneficial if the water had again fallen a low stage after its completion. The indications on figure 4 can not be entir relied on, as they represent results obtained by reducing a survey made at a sta considerably above a low-water stage.

PLATE NO. 5, CHEROKEE CROSSING (89 R).

This plate shows the results of the work at Cherokee Crossing by the dred *Alpha* and *Beta*. Figure 1 indicates the condition September 4, 1896, 3 days bef dredging by the *Alpha*; figure 2, September 23, 1896, 3 days before dredging was co pleted by the *Alpha*; figure 3, October 2, 1896, 6 days after completion of dredging the *Alpha*; figure 4, October 15, 1896, 1 day before dredging the second time w begun by the *Beta*; figure 5, October 21, 1896, 2 days after dredging by the *B* was stopped; figure 6, November 4, 1896, 1 day before dredging the third time w begun by the *Beta*; figure 7, November 14, 1896, 2 days after dredging had been co pleted by the *Beta*; figure 8, December 2, 1896, 20 days after dredging had been co pleted by the *Beta*.

From figure 1 it would seem that the 9-foot curves in the upper and lower po were originally separated by a reef 1,100 feet wide at the narrowest point, and th when reduced to the lowest stage of the season there was only a practicable dep of about 5 feet across the bar. The curves of the preliminary survey seem to in cate that the lower extremity of the cuts should have been 200 feet further dow stream than the location selected. When the dredging was completed there w reported to be a channel 8½ feet deep and 200 feet wide at a stage about 2 feet abo the lowest stage of the season.

Figure 2 was a survey made before the completion of the dredging, during a vi made by me to the dredge. It indicated a deepening of about 2 feet over the ar covered by the dredging, with a practicable channel nearly 7 feet in depth at t lowest stage.

In figure 3 a narrow 7-foot channel follows along the cuts made by the dredge, b it will be noted that a much better channel has developed about 600 feet below t cuts and separated from them by a lump with only 3½ feet of water on it. The su vey does not extend far enough down to show the connection of this channel wi the lower pool, but the depths at the crossing of the lower reef probably do n exceed 7 feet. This channel developed to such an extent that on October 15 t 9-foot curves of the upper and lower pools had joined together, leaving a narrow 9-fo channel entirely across the reef.

The dredging done by the *Alpha*, therefore, increased the depth about 2½ feet the vicinity of the cuts. But the development of a natural channel further do and the downstream movement of the upper reef seems to indicate that the chann would have been more successfully maintained subsequently if located farther dow The condition of the crossing after dredging was certainly better than before. T dredge, however, did not succeed in connecting the 9-foot curves in the upper a lower pools. The general result of the work can not be regarded as satisfactory.

In figure 4 is shown the survey made prior to the beginning of dredging by t *Beta*. As indicated on the figure, there is a narrow but practicable 9-foot chann across the bar about 800 feet below the cuts made by the *Alpha*. Between this a the *Alpha's* channel there is a lump about 175 feet wide and 500 feet long on which the depth is less than 4 feet. The main portion of the *Beta's* cuts are in this channel except at the upper end, where they left the channel on the downstream side.

The conditions October 21, 2 days after dredging was suspended on account of a rise in the river, are shown in figure 5. At this time only about two-thirds of the dredging contemplated had been completed. There was shallow water both above and below the cuts. There is now a practicable channel about 8 feet in depth, with a pool in the middle of the crossing about 300 feet wide and 1,200 feet long, with depths ranging from 9 to 11¼ feet. This pool lay along the axis of the cuts and is clearly due to the work of the dredge.

In figure 6 we see great changes have occurred. The upper pool shows a decided tendency to break through the reef into the lower pool, the direction of the channel following close along the dredge cuts except at the lower end, where it is crowded down by the upper reef. The 11-foot curve reaches down from the upper pool directly toward the upper end of the cuts. There is a practicable channel 8¼ feet deep and a 7-foot channel 600 feet wide.

The effect of this deepening has evidently been to close up the channel of the *Alpha*, though the depths are somewhat greater in the vicinity of this old channel than when dredging first began.

In figure 7 we have the conditions immediately after the completion of dredging. There is now a practicable 11-foot channel from the upper pool to the lower pool. The 9-foot channel is 200 feet wide, and is a straight, easy channel to run. The upper reef, however, crowds down close to the edge of the cut.

In figure 8 the 9-foot channel still remains practically on the lines of the cuts. The 11-foot channel shown on figure 7 is now reduced to occasional pools from 11 to 13 feet deep. The outlines of the 9-foot channel are very irregular. The lump near the lower end shows a shoaling of about 2 feet without much change of position. This last survey was made at a time when the river was rising at the rate of about 2 feet per day.

The location selected for improvement by the *Beta* appears to have been the proper one and the results of its dredging are most satisfactory.

PLATE NO. 6, HATHAWAYS LOWER CROSSING (102 L).

The four figures on this plate show the condition October 8, 1896, 2 days before dredging by the *Beta;* October 20, 1896, 6 days after dredging; November 7, 1896, 24 days after dredging, and December 1, 1896, 48 days after dredging.

At the time of the first survey, shown on figure 1, there was a practicable channel 9 feet deep and about 100 feet wide. The location of the dredging cuts does not cover this channel, but lies from 200 to 300 feet above it and across a lump with less than 7 feet of water on it. The dredge cuts are evidently too high upstream, as they are along the axis of a reef which has deeper water on both sides of it, the best channel being below. The shortest distance between the 11-foot curves of the upper and lower pools is about 850 feet. The average depth in the area covered by the dredge is 8½ feet, with a least depth of 6.2 feet.

Figure 2 shows a 9-foot channel about 1,000 feet wide, with the exception of some narrow lumps. The 11-foot curves are only 200 feet apart, and there is a practicable channel with a depth of over 10 feet. The average depth in the dredged area is 10.6 feet, an increase of 2.1 feet over that shown in figure 1.

Examination of figure 3 shows that great changes have occurred and the bar has encroached on the dredged area on both the upper and lower sides. At the lower end of the cuts, which on October 20 showed a depth of 11 feet or over, there is now less than 8 feet; at the upper angle, where there was over 9 feet, less than 8 feet is now found. The 11-foot curves have receded and are now about 600 feet apart. There is, however, a good channel 400 feet wide with a least depth of 9.7 feet, which lies directly across the dredge cuts. The upper reef, through which the cuts were made, again shows a tendency to develop, and extends from the dry bar partially over the cuts. The lower point of the dry bar has also been extended downstream. The channel is, however, still satisfactory.

In figure 4 marked evidences of deterioration are apparent. The 9-foot channel is exceedingly irregular and narrows down to about 100 feet in width. This channel would be a very difficult one to navigate. The upper-bar reef has extended down so as to cover about one-half of the dredged area. The lower reef has also somewhat encroached on the channel. The average depth in the dredged area is 9.2 feet. This last survey was made at the beginning of a very sharp rise, amounting to 11 feet in about 8 days.

Considered as a whole, the results of the work at this point can not be considered wholly satisfactory. The result of the work would have probably been better if the dredge cuts had been originally located farther down and the existing steamboat channel shown on fig. 1 had been selected for improvement. The period covered

by these surveys, however, shows first a rise of about 6 feet in as many days, ther
stationary stage for about three days, followed by a fall of 6 feet in the next t
days. The dredging was during the rising stage, which for a time was at the ra
of an inch in an hour. The decline was equally rapid. These conditions, it mu
be admitted, are extremely unfavorable for the maintenance of dredged channe
From October 27 to December 1 the river gradually rose about 3 feet, with sm
oscillations intervening.

PLATE NO. 7, OSCEOLA BAR (164.5 R).

The three figures show the condition on September 30, 1896, just before dredgin
October 5, 1896, one day after dredging was completed, and November 29, 1896, fif
six days after dredging had been completed.

In fig. 1 the distance between the 9-foot curves is 600 feet and there is a practic
ble channel with about 7½ feet on the shoalest part of the reef. The direction of t
curves would indicate that the cuts should have been made 150 feet farther dow
stream, so as to reach the upper pool at its lower extremity. This would ha
shortened the cut materially, and would also have kept it well below the upper re

In fig. 2 the effect of the dredging is plainly shown, as the 9-foot curves of t
upper and lower pools are now joined, and the 11-foot curves, which were 900 fe
apart, are now only 150 feet apart, and there is a practicable channel 10 feet de
and 250 feet wide. In the area covered by the cuts the river bed has been lower
an average of about 4 feet. The channel is straight and easily run.

In fig. 3 we have the conditions nearly two months after the dredging was co
pleted. In the meantime there has been a rise and fall of 5 feet in the stage of t
river: The channel has moved downstream, the upper bar has moved down partia
across the cut, but the conditions are still better than at any previous time. T
9-foot channel is now 560 feet wide, and even the 11-foot curves of the upper a
lower pools are now joined. Depths of over 13 feet are now found where the dept
were 8 feet or less.

During the period covered by these surveys the stage of the river went throu
several phases of rise and fall, as may be seen from an inspection of the Memp
hydrograph between September 30 and November 29. Between September 30 a
October 7 the river fell 1 foot, from October 7 to 13 it rose 5 feet, then was stationa
for about 4 days, and during the next eleven days fell 5 feet. It remained practica
stationary for more than two weeks to November 8, when a gradual rise set in a
continued throughout the month of November, showing a rise in that time of ab
4 feet.

The improvement resulting from the dredging of this bar is very evident and cou
possibly have been made still greater by locating the cuts lower down.

PLATE NO. 8, ISLAND NO. 34 (179 R).

The three figures show the condition September 22, 1896, three days before dred
ing; October 2, 1896, three days after dredging; November 28, 1896, 60 days af
dredging.

In fig. 1 the distance between the 9-foot curves in the upper and lower pools w
about 200 feet, with a practicable channel of 8¼ feet. The average depth of t
area bounded by the outside limits of the cuts was 10.2 feet. The curves indic
that the shore channel next to Island 34 should have been selected for improveme
instead of the one actually adopted.

In fig. 2 we see that a 9-foot channel runs through and along the location of t
dredge cuts, but that a channel of equal depth has broken through next to the sh
of the island. There is a practicable channel both ways of 9.3 feet, with a mark
improvement of the lower part of the channel. The lower limits of the 11-fo
curve in the upper pool have remained in about the same position, while in the low
pool the 11-foot curve has moved downstream some 300 feet. The breaking throu
of the shore channel has tended to fill the channel along the line of dredging a
shift it nearer to the shore of the island. The reef lying across the cuts and abo
the middle of the same apparently remains with about the same depth at the cu
as before dredging, although the dredge moved the material for a depth of about
feet. In other words, the break through the reef has not been made along the li
of the cuts, but the dredging may be the primary cause of this improved conditio
It shows a depth of 9.3 feet, as against 8 feet before dredging.

In figure 3 the reef again extends across the 9-foot channel, with a least depth
7.5 feet along the line of the cuts and a practicable channel of 8.2 feet, or about t
same as before dredging was begun. The distance between the 9-foot curves alo
the cuts is about 400 feet. The reef is now near the lower end of the cuts, so
300 feet lower than when the first survey was made. In the upper pool the 11-fo
curve has also moved down about 600 feet. From near the lower end of the cu

down the channel shows a decided improvement in both width and depth. The distance between the continuous 11-foot curves in the upper and lower pools is now only about 1,100 feet, as against 2,300 feet when dredging began. The lower pool has moved upstream. The shore channel already referred to has been cut off and reduced to about the same condition as existed before dredging, and the indications are that the head of this channel should have been the one selected for improvement.

The controlling depths on the crest of the bar in figure 3 show little or no improvement over the conditions before dredging was done, although the channel both above and below is better. The average depth in the cuts is about 9.5 feet. In the intervals between the three surveys the river rose 1¼ feet, then fell the same amount; then rose 5 feet in 7 days and fell 5 feet in the next 11 days. After remaining stationary for two weeks, there came a gradual rise of about 4 feet in 12 days. The results of the dredging are not satisfactory.

PLATE NO. 9, ISLAND NO. 40 (211 L).

The four figures show the condition August 31, 1896, 1 day before dredging began; September 7, 1896, 5 days after dredging was stopped the first time; September 20, 1896, 2 days after dredging was completed the second time, and November 27, 1896, 70 days after dredging was completed the second time.

In figure 1 the distance between the 9-foot curves in the upper and lower pools is 1,300 feet, with a practicable channel 6 feet in depth. The location selected starts from near the upper end of the lower pool and points to the lower end of the upper pool. In the dredged area on this figure the depths averaged a little less than 5 feet.

In figure 2 we see the conditions about a week after the first survey was made. It shows great changes from natural causes. The main upper and lower pools have remained about the same, but the crossing has deepened very materially, and there is a practicable channel along the line of the cuts of 7 feet or over. Two 9-foot pools have developed in the crossing, and the average depth in the dredged areas has increased over 2 feet.

In figure 3 a practicable channel is found over 9 feet in depth, with a least width of about 200 feet and a distance of only 700 feet between the 11-foot curves. The average depth in the dredged areas is about 11 feet, an increase from the first condition of about 6 feet.

In figure 4 we see that the 9-foot channel has widened to over 450 feet, and there is a practicable channel about 10 feet in depth. The average depth in the dredged area is still about 11 feet.

During the period covered by the surveys shown on the plate the stage of the river fell from 8 feet to 1.8 feet; it then rose to 4 feet and fell again to 2.4 feet; then rose to 7.8 feet and fell to 2.4 feet, followed by another rise reaching 6 feet.

Considered as a whole, the location selected could not have been improved upon, and the results of the dredging are extremely satisfactory.

SUMMARY.

The results discussed may be summarized as follows:

At Compromise Bar (77 L) a good channel was opened by the *Alpha*, and maintained itself for some time. Even at the end of the season well-defined traces of the work existed.

At Upper Point Pleasant Bar (79 R) an effort was made to open the channel along the shore by the *Alpha*. While the river bed was lowered to a certain extent along the cuts, the work was practically obliterated and no benefit to navigation resulted; this failure being due, first, to an improper selection of the line for dredging, and, second, to the inability of the *Alpha* to work at a greater depth than 12 feet.

At Lower Point Pleasant Bar (79.5 R) a channel was opened by the *Beta* and a straight channel nearly 11 feet deep was carried through the reef where there was formerly only about 7 feet of water. Thirty-three days after dredging, however, an examination shows the channel to have been entirely obliterated by a reef which covered it squarely, leaving a depth of less than 5 feet along the line of the former channel. Another good channel, however, developed lower down.

At Cherokee (89 R) the channel was improved to a limited extent by the *Alpha*, but this improvement entirely disappeared later in the season. The location selected by the *Alpha* was too high up and was blocked by the closing in of the bar from above. The *Beta*, selecting a site further down, made a second attempt, which work was suspended by orders from this office before completion. On the river falling the *Beta* resumed work on the same site, and a good 9-foot channel was opened through the reef. This channel remained to the end of the season.

At Hathaways Lower Crossing (102 L) a good channel was opened which remained in good shape for at least a month, but twenty-three days later there was a marked deterioration. The site selected for dredging at this point could probably been improved upon.

At Osceola Bar (164.5 R) an excellent channel was opened, which was still factory at the date of the last survey.

At the foot of Island 34 (179 R) a channel was opened and maintained f unknown length of time. But a survey two months after the completion o dredging indicates no improvement over the original state of affairs. The in tions here are that the difficulty was due to the selection of the wrong channe improvement.

At the chute of Island No. 40 (211 L) the channel shows a marked improveme a result of dredging, and this improvement continued two months after the dred was completed.

Considered as a whole, the results are favorable to dredging as a temporary dient for the improvement of navigation on the Lower Mississippi River. They phasize very strongly, however, the importance of the proper location of the cha and indicate, generally speaking, that careful surveys are as important in the d mination of this question as any other consideration. The percentage of success the *Beta* was larger than with the *Alpha*, which was due to the greater experien the assistant engineer in charge of the *Beta*, and to the fact that the stage of throughout the season was above what might be termed even ordinary low w The *Alpha's* suction is unable to dredge to a greater depth than 12 feet, wherea *Beta's* suction was frequently lowered to over 16 feet; in consequence, much o work of the *Alpha* could not have been more than simply scraping over the sur In addition, the pump and engines of the *Alpha* were not properly overhauled put in condition for the season's work, and the proportion of breakdowns was greater in consequence than could have been ordinarily expected.

The question of the advantage of the *Beta's* cutters still remains unsettled. ing some of the breakdowns of the cutter machinery this dredge was operated wit any use of the cutters. Of course under these circumstances her progress a was impeded a great deal more than it would have been with no cutters at all the immersion of the floating pipes seemed to show that the same amount of mat was passing through the suction with the cutters as without.

CONCLUSIONS.

The following conclusions arrived at by J. A. Ockerson, principal assistant eng at this office, after a complete study of the subject, are thoroughly concurre by me:

"There can be but little doubt that the secret of success at any particular ba in the proper selection of the lines on which the cuts are to be made. This is as important as the efficiency and proper management of the plant itself, a much more difficult, as no fixed rules can be laid down to cover conditions w differ with each bar and vary continually from day to day at any one bar.

"It is not too much to say that the success or failure of dredging as an expe for the relief of navigation depends more on the proper selection at each bar o location of the line on which dredging is to be done than on any other one th Good judgment in such selection can only be derived from long familiarity with careful study of river phenomena. Such judgment, aided by a minute surv the crossing under consideration, will go far toward solving the most difficult fea of the dredging problem. Omit either one or both of them, and the chances of fa are good.

"It will be inferred from the above that a good survey covering the entire affected should first be made and carefully studied. The soundings should close together as practicable, and the sections should not be over 50 feet apa the shallow portions of the reef and 100 to 150 feet apart over the deeper a There are very few cases where the omission of this preliminary work is justifi The time spent in such survey and examination is amply covered by the time s in the far more expensive operation of dredging. The work can be, and shoul so planned as to have the survey completed and the axis of cuts located by the the dredging plant arrives on the scene. During the work at any bar, the s should be carefully determined from a reliable gauge connected with stable b marks. The stage should be read and recorded three times a day.

"It is evident from an examination of the plats submitted that there is a ge downstream movement of the reefs. In most cases where these reefs are steep well defined along the edge of the lower pool, as at Osceola Bar, Hathaways, C okee, and Lower Point Pleasant, they lie parallel to the shore. At the edge of reef there is therefore a cross current, and the water running along the pool is q swift, the general direction of the current being parallel to the reef. The u part of this reef is generally described as a 'tailing down' of the bar above.

downstream movement continues and forms a very important factor in the proper location of the cuts. Judging from the experience of last season, the cuts should be located as far downstream as practicable, so as to keep the cuts from being filled up by the elongation of the upper bar.

"In the case of wide, flat bars with no decided reef and the channel depressions badly divided, the only hope of success lies in opening a deep cut as rapidly as possible. The indications from experience thus far are that such opening should begin at the upper end, so as to leave a clear, open cut and avoid the deposit which is left astern of the dredge when working upstream.

"The data needed for determining the amount of material removed are doubtless very deficient. Owing to the tendency to fill, as noted above, depths taken astern of the dredge when working upstream can not be regarded as a measure of the depths of material removed. A better measure of this quantity would be the depths taken at the bow of the dredge behind the cutters.

"As a general rule, the following soundings should be taken at intervals of 15 minutes while the dredge is in operation: Working upstream; 30 feet ahead of the cutters or suction in line with each side of the dredge, behind the cutters as near the dredge as practicable, one on either side amidship, and one on either side of floating pipes, making two astern. Working downstream; two soundings astern, located about one-fourth of the width from either side of hull, one on either side amidship, two at the hull below the cutters, two about 30 feet above the cutters. An effort should also be made to secure soundings at the outer edges of the slopes of each cut shortly after dredging.

"These soundings should be entered in a notebook having suitable headings, so that the record would be clear and reliable. These data, together with the length and width of the cut, would be ample for computing the approximate volume of each cut. The exact volume handled by the pumps is an indeterminate quantity, for reasons already fully explained, unless a test barge or similar means is used. It is doubtful whether the method used last season of determining the volume moved by measuring the changes occurring over a large area is of any value. If this is desirable, then the soundings taken before and after dredging should be very numerous. The cross sections should not exceed 25 feet apart and the soundings on each section should be as close as correct soundings can be taken. These should be platted on a scale large enough to give accurate measurements. The areas of the platted sections could be computed or measured with a planimeter, and the volume of material above a given datum within the limits decided upon could be deduced with considerable accuracy. The difference between the volumes as determined before and after dredging would be a measure of the total change that had occurred, whether due to dredging or to natural causes.

"The relation between the direction of the current and axis of the cuts is also important. Generally speaking, the cuts should be practically parallel to the general direction of flow at the low-water stage. As the stage changes, the direction of flow changes, and finally the flow may be square across the cut. This is probably one of the most active agents in obliterating channels opened by dredging or even natural channels. On this account it might be well, when a favorable place is found, to lay out a line for dredging which will be practically parallel to medium or high-stage conditions, so as to ascertain whether a channel opened in this way would maintain itself better during changes of stage than a channel opened in the usual way. There are, of course, many cases where it would be impracticable.

"The great advantage of having a suction designed so as to be able to dredge both up and down stream has been fully established, and such suction should be put in operation on all of the dredges as soon as practicable."

In addition to the above, I think the necessity of a close supervision of the dredging work on the ground is evident, and the surveys should be conducted and the dredges located as nearly as practicable under the direct supervision of the engineer officer in charge. During the past year, with the great amount of dredge construction going on, I have been unable to give dredge operations the personal attention that they required, but during the coming low-water season either myself or the principal assistant engineer will be present on the ground most of the time for the purpose of personally directing all movements of the dredges in commission instead of allowing isolated operations by each dredge party as heretofore.

Very respectfully, your obedient servant,

H. E. WATERMAN,
Captain, Corps of Engineers,
Secretary Mississippi River Commission.

Col. G. L. GILLESPIE,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

APPENDIX 7 D.

REPORT OF MR. J. A. OCKERSON, ASSISTANT ENGINEER, ON THE FIELD AND O
WORK PERTAINING TO SURVEYS, GAUGES, AND OBSERVATIONS, AND ON THE
STRUCTION AND OPERATION OF DREDGES.

ST. LOUIS, MO., *May 31, 1*

SIR: I have the honor to make the following report on the field work, office r
tion and mapping pertaining to surveys, gauges, and observations on the M
sippi River and tributaries and on the construction of dredges and their ope
on the Mississippi River below the mouth of the Ohio.

THE GENERAL SURVEY OF THE MISSISSIPPI RIVER FROM THE HEAD OF PASS
THE HEAD WATERS.

The survey was resumed on May 29, 1896, at Arnolds Landing, Ill. (591 miles
Cairo), which is the upper limit reached during the season of 1895. The high
of river prevented earlier resumption of the field work.

The party was organized as follows: A. T. Morrow in charge; W. G. Co
Geo. H. French, W. S. Williams, O. N. Axtell, F. G. Ray, M. I. Powers, and
Axtell, on topography; C. G. Weyl and John Wade, ordinary levels; T. C.
ridge and L. C. Dziatzko, hydrography; Gustav Bischoff and A. N. Dunaway,
ting; C. V. Seastone, hydrography and platting. In addition to the above
was a steamboat crew and laboring force, making a total of about sixty pe
This party was quartered on the steamer *Patrol* and survey boat *Illinois*.

Owing to the high stage of the river the work was confined to topograph
levels along the bluffs and high ground for a period of nearly two months. I
way a stretch of about 100 miles of river was covered between Arnolds Landin
Prairie du Chien before the river reached a suitable stage for surveys of the
and lowlands.

On July 26 the party turned back to Arnolds Landing and took up the hy
raphy and topography of the bottom lands and sand bars. This work was
pleted to near Prairie du Chien on September 11. After that date to the end o
season, which closed near Brownsville, Minn., on November 6, the topograph
hydrography were carried along together, making the work complete as the
moved upstream.

The work was suspended on account of the cold weather and a rise in the
which made satisfactory work impracticable.

The party was disbanded and paid off by Assistant Engineer J. A. Ockers
La Crosse, Wis., on November 7. The engineers were transferred to the secre
office in St. Louis, where the work of reducing and platting the notes of the se
work was carried on during the winter. The steamer *Patrol*, survey boat *Il*
and fuel barge were taken to Lansing, Iowa, and placed in winter quarte
charge of T. C. Hockridge.

The general plan of work described in previous reports was carried out. Th
tribution of the parties during the first two months was modified owing t
absence of hydrographic work, and during the third month (covering the same
of the river the second time), owing to the work being confined to the bottom
the hydrography. The results do not show any great loss of time in this meth
covering the ground twice, and it does add very materially to the length o
season.

Good, satisfactory results can only be obtained by surveying the river an
bars and lowlands at a low stage. If the whole work was confined to low-
periods only a very short season would be available.

Above the mouth of the Wisconsin River the work becomes more intricate
anything previously met with. The river separates into a network of sloug
chutes and the hills are high and considerably broken. These conditions wil
tinue for some distance northward.

The following summary shows the amount of work done during the field seas

Miles of main river surveyed (channel distance)	
Number of square miles of topography	
Number of square miles of hydrography	
Number of soundings	48,
Number of sextant angles read	5,
Number of distances read to locate soundings	14,
Number of elevations determined by ordinary levels	12,
Total number of instrumental locations in topography	176,
Total number of elevations determined in topography	151,
Average number of instrumental locations per square mile of topography	
Average number of elevations determined per square mile of topography	

The discrepancies between the results of precise and ordinary levels are shown in the following table:

TABLE NO. 1.—*Discrepancies between the results of precise and ordinary levels.*

Between—	Distance.	Closure.	Ordinary levels run by—
	Miles.	*Feet.*	
P. B. M. 312 and B. M. ^{149}	12	+0.05	C. G. Weyl.
P. B. M. 312 to 310	1.7	+ .09	Do.
P. B. M. 310 to 308	1.7	— .03	Do.
P. B. M. 308 to 306	1.2	+ .02	Do.
P. B. M. 306 to 302	1.4	— .06	Do.
P. B. M. 302 to 301	2	+ .05	Do.
P. B. M. 301 to 299	2	+ .06	Do.
P. B. M. 299 to 296	1.9	— .01	Do.
P. B. M. 296 to 294	1.8	— .03	Do.
P. B. M. 294 to 292	1.1	— .04	Do.
P. B. M. 292 to 289	4.2	+ .02	Do.
P. B. M. 289 to 287	2.5	+ .07	Do.
P. B. M. 287 to 285	2.2	+ .05	Do.
P. B. M. 285 to 283	1.6	— .05	Do.
P. B. M. 283 to 281	1	— .06	Do.
P. B. M. 281 to 279	1	— .07	Do.
P. B. M. 279 to 278	.8	+ .02	Do.
P. B. M. 278 to 277	2.2	+ .02	Do.
P. B. M. 277 to 272	4.8	+ .10	Do.
P. B. M. 272 to 270	2.8	.00	Do.
P. B. M. 270 to 268	1.5	— .03	Do.
P. B. M. 268 to 266	1.6	+ .04	Do.
P. B. M. 266 to 264	1.4	+ .03	Do.
P. B. M. 264 to 262	2	.00	Do.
P. B. M. 262 to 261	.8	— .05	Do.
P. B. M. 261 to 259	3.7	+ .15	Do.
P. B. M. 259 to 257	2	+ .10	Do.
P. B. M. 257 to 255	2.1	— .06	Do.
P. B. M. 255 to 254	1.9	+ .02	Do.
P. B. M. 254 to 252	2.7	— .02	Do.
P. B. M. 251 to 250	4.4	— .01	Do.
P. B. M. 250 to 247	2	+ .08	Do.
P. B. M. 248 to 246	2.4	+ .06	Do.
P. B. M. 246 to 244	2.5	.00	Do.
P. B. M. 244 to 242	2	+ .01	Do.
P. B. M. 242 to 241	3.1	+ .07	Do.
P. B. M. 241 to 240	3.3	— .05	Do.
P. B. M. 240 to 238	2.7	+ .03	Do.
P. B. M. 238 to 237	1.4	— .02	Do.
P. B. M. 237 to 235	1.9	— .03	Do.
P. B. M. 235 to 233	1.4	+ .05	Do.
P. B. M. 326 to T. B. M. 340	4	— .05	John Wade.
T. B. M. 340 to P. B. M. 322	.5	.00	Do.
P. B. M. 324 to 322	4	+ .14	Do.
P. B. M. 322 to 318	1	+ .02	Do.
P. B. M. 232 to 230	5.5	— .06	Do.
P. B. M. 230 to 227	4	+ .02	Do.
P. B. M. 227 to T. B. M. 213	5	+ .06	Do.
T. B. M. 213 to 209	4	+ .13	Do.
T. B. M. 209 to P. B. M. 223	2	+ .03	Do.
P. B. M. 223 to T. B. M. 207	1	+ .01	Do.
P. B. M. 223 to 222	1.5	+ .01	Do.
P. B. M. 222 to 220	3	— .14	Do.
P. B. M. 220 to 218	4.5	— .02	Do.
P. B. M. 218 to 216	2	+ .03	Do.
P. B. M. 216 to 214	3	+ .01	Do.
P. B. M. 214 to 212	2	— .08	Do.
P. B. M. 212 to 211	1	— .04	Do.
P. B. M. 211 to 210	4	— .13	Do.
P. B. M. 210 to 208	4	— .02	Do.
P. B. M. 208 to 207	1.5	— .02	Do.
P. B. M. 207 to 205	4.5	+ .04	Do.
P. B. M. 205 to 203	4.5	.00	Do.
P. B. M. 203 to 202	2	— .01	Do.
P. B. M. 202 to 200	3	+ .06	Do.

The discrepancies between the results of the two lines of ordinary levels w
are connected at intervals of about 3 miles are shown in the follwing table:

TABLE No. 2.—*Discrepancies between the results of the two lines of ordinary levels,*
necting at successive stone lines.

[Levelers: Right bank, C. G. Weyl; left bank, John Wade.]

NOTE.—Owing to the high water in first part of season the ground between Apple River (ston
169) and above Prairie du Chien (stone line 199) was gone over twice. Where connections were
on the first survey they are marked "No. 1."

At stone line—	Discrepancy.	At stone line—	Dis
	Foot.		
170	0.00	190	
171	(*a*)	191, No. 1	
172	− .13	191	
173	.00	192, No. 1	
174	.00	192	
175	+ .08	193, No. 1	
176, No. 1	+ .14	193	
176	− .04	194, No. 1	
177, No. 1	− .04	194	
177	− .11	195, No. 1	
178, No. 1	− .08	195	
178	+ .13	196	
179, No. 1	+ .04	197	
179	+ .03	198, No. 1	
180	(*a*)	198	
181, No. 1	− .12	199, No. 1	
181	+ .04	199	
182, No. 1	− .05	200	
182	− .06	201	
183	− .11	202	
184	− .08	203	
185, No. 1	− .08	204	
185	+ .13	205	
186, No. 1	− .06	206	
186	+ .01	207	
187, No. 1	− .09	208	
187	+ .11	209	
188, No. 1	− .05	210	
188	+ .05	211	
189, No. 1	− .09	212	
189	− .04	213	
190, No. 1	+ .07		

a No crossing. *b* No connection from 204.

The elevation of the water surface above the datum was determined with Y-le
at frequent intervals on both sides of the river, and from these values the sur
slope has been deduced as given in the following table:

TABLE No. 3.—*Slope of water surface in the Mississippi River between successive*
lines from foot of Coon Slough, Wisconsin, to Apple River, Illinois, June 1 to Nove
6, 1896.

Number of stone line.	Location of stone line.	Elevation of water surface above Memphis datum.*a*	Total slope between lines.	Midstream distance between lines.
		Feet.	*Feet.*	*Miles.*
212	Opposite foot of Coon Slough	627.06		
211	At Genoa, Wis	626.18	0.88	3.27
210	3 miles below Genoa, Wis	625.37	.81	2.55
209	1 mile above Victory, Wis	624.58	.79	3.42
208	3 miles above De Soto, Wis	624.06	.52	3.05
207	Lower end of De Soto, Wis	623.11	.95	3.30
206	1 mile above Lansing, Iowa	621.40	1.71	3.54
205	2¼ miles below Lansing, Iowa	620.76	.64	2.77
204	At Ferryville, Wis	620.42	.34	2.80
203	2¼ miles above Lynxville, Wis	619.42	1	3.27
202	1¾ miles below Lynxville, Wis	617.36	2.06	4.91
201	1½ miles above Harpers Ferry, Iowa	616.63	.73	2.92
200	1¾ miles above Waukon Junction, Iowa	615.69	.94	3.39
199	Upper end of Johnsonport, Iowa	614.88	.81	2.89

a Elevations reduced to stage of October 15, 1895, 9.30 a. m.

TABLE NO. 3.—*Slope of water surface in the Mississippi River, etc.*—Continued.

Number of stone line.	Location of stone line.	Elevation of water surface above Memphis datum.[a]	Total slope between lines.	Midstream distance between lines.	Slope per mile.
		Feet.	*Feet.*	*Miles.*	*Feet.*
198	3 miles above Prairie du Chien, Wis	614.50	.38	2.80	.136
197	At Prairie du Chien, Wis	613.99	.51	3.27	.156
196	One-half mile above Wisconsin River	613.42	.57	3.11	.183
195	At Wyalusing, Wis	611.99	1.43	4.04	.354
194	One-fourth mile above Clayton, Iowa	611.26	.73	2.50	.292
193	1 mile below Bagley, Wis	610.60	.66	2.92	.226
192	One-half mile above Glen Haven, Wis	609.63	.97	3.33	.291
191	Upper end of Guttenberg, Iowa	608.24	1.39	2.86	.486
190	2 miles below Guttenberg, Iowa	606.48	1.76	2.92	.603
189	2¼ miles above Cassville, Wis	604.84	1.64	3.85	.426
188	One-half mile below Cassville, Wis	604.03	.81	2.52	.321
187	One-half mile below Buena Vista, Iowa	603.18	.85	3.02	.281
186	One-fourth mile below Waupeton, Iowa	602.15	1.03	3.21	.321
185	Three-fourths mile below Finley Landing, Iowa	601.07	1.08	3.35	.322
184	1¼ miles above Spechts Ferry, Iowa.	600.37	.70	3.02	.232
183	1½ miles below Spechts Ferry, Iowa	598.63	1.74	3.08	.565
182	1 mile above Sinope, Wis	596.96	1.67	2.95	.563
181	3 miles above Dubuque, Iowa	595.88	1.08	4.17	.251
180	Three-fourths mile above Dubuque, Iowa	594.77	1.11	2.70	.411
179	3 miles below Dubuque, Iowa	594.22	.55	4.04	.136
178	6 miles below Dubuque, Iowa	593.21	1.01	3.21	.315
177	9 miles below Dubuque, Iowa	592.17	1.04	3.30	.315
176	1 mile above Gordons Ferry, Iowa	590.38	1.79	3.21	.558
175	2 miles below Gordons Ferry, Iowa	589.61	.77	2.95	.261
174	3 miles above Bellevue, Iowa	588.32	1.29	4.20	.307
173	Upper end of Bellevue, Iowa	587.58	.74	2.64	.280
172	3 miles below Bellevue, Iowa	586.31	1.27	3.08	.412
171	6 miles below Bellevue, Iowa	585.56	.75	3.39	.221
[b]170	1 mile below mouth of Maquoketa River	585.37	.19	2.01	.095
169	At Arnolds Landing, Illinois	584.01	1.36	4.26	.319

[a] Elevations reduced to stage of October 15, 1895, 9.30 a. m.
[b] Maquoketa River in flood at time levels were taken.

A list of all the bench marks of permanent value, high water marks, gauges, bridges, base of rails, etc., whose elevations were determined during the season are enumerated in the following table:

TABLE NO. 4.

DESCRIPTIONS OF BENCH MARKS BETWEEN ARNOLDS LANDING, ILLINOIS, AND NEAR BROWNSVILLE, MINN., WITH ELEVATIONS IN FEET ABOVE THE MEMPHIS DATUM.

[Mean Gulf level at Biloxi, Miss., preliminary value, is 8.13 feet above the Memphis datum. R. B. signifies right bank and L. B. signifies left bank.]

U. S. P. B. M. 323. Is on left bank opposite the foot of Island No. 256, about 574 feet back from high-water line, over beyond top of same bluff on land of Mrs. McCabe, widow, about one-half mile south of Benjamin Hatfield's house, and 62 meters south of west of a 3-foot oak tree standing in field, at point of brush and head of small valley running east by the wire fence on south side of field, being a copper bolt in tile set about 3 feet under surface of ground. Elevation, 630.89.

U. S. P. B. M. 324. Is top of cap on iron pipe set over P. B. M. 323. Elevation, 634.89.

T. B. M. 340. Is on left bank about 2 miles below Harris Landing, 361 feet below small ravine in sand bluff, at foot of bluff on a lone blazed cottonwood tree about 28 inches in diameter, on northwest root, being top of large spike. Elevation, 595.30 feet.

STONE LINE 170 (ABOUT THREE-FOURTHS MILE ABOVE ISLAND NO. 256).

$\frac{170}{1}$. Tile and pipe one-half meter south of fence on north side of wagon road on line of division fence of Warner and A. O. Hunt, on sand prairie 1,356.8 meters back of B. M. $\frac{170}{2}$.

Elevation cap on pipe, 642.34. Bolt in tile, 638.31.

$\frac{170}{2}$. Tile and pipe on Illinois shore about three-fourths mile above head of Island No. 256, on very high sand hill. A small bunch of trees stands directly between river and B. M. Sand hill is the most prominent one in the vicinity.

Elevation cap on pipe, 673.69. Bolt in tile, 669.71.

$\frac{170}{3}$. Tile and pipe 30 meters from river bank in thick timber one-fourth mile above

Island No. 256, 1¼ miles below mouth of Maquoketa River. On south bank of s slough leading back from river. To 8-inch tree 160°—5.5 meters; to 10-inch 60°—7.6 meters; to 8-inch tree 310°—5.8 meters.

Elevation cap on pipe, 595.52. Bolt in tile, 591.54.

$\frac{170}{4}$. Tile and pipe 20 meters from west bank of small dry slough, in open bot land, 746 meters from river bank, in open pocket in timber extending to bluffs or west, 60 meters west of edge of timber. To 36-inch elm 108°—20.1 meters; to 30- elm 154°—38.7 meters; to 14-inch cottonwood 266° 30′—46.3 meters.

Elevation cap on pipe, 596.06. Bolt in tile, 592.05

U. S. P. B. M. 321. Is on left bank about 1¼ miles below Harris Landing and 1¼ r above Island No. 256, back from the top of sand bluff, under the east fence of h way, 31 feet southeast from cattle pen, under wagon road leading from pas through cattle chute to river, northeast from two large honey-locust trees stan in said chute at top of bluff, being copper bolt in tile set 3 feet below surface. vation, 626.71.

U. S. P. B. M. 322. Is top of cap on iron pipe set over P. B. M. 321. Elevation, 63

U. S. P. B. M. 319. Is on left bank at Harris Landing, Illinois, on Jackson Har farm, now occupied by L. T. Green, 207 feet below his house, in the roadside, close to east fence, 3 feet below the fence at south side of dooryard, at the north of the lilac hedge, being copper bolt in tile set 3 feet underground. Elevation, 61

U. S. P. B. M. 320. Is top of cap on iron pipe set over P. B. M. 319. Elevation, 62

U. S. P. B. M. 317. Is on left bank at Harris Landing, Illinois, on land owne Jackson Harris, on the east side of highway on top of sand bluff, 184 feet a the house now occupied by L. T. Green, in northwest corner of small field a the dooryard, very close to roadside fence, being top of copper bolt in tile set 3 underground. Elevation, 617.78.

U. S. P. B. M. 318. Is top of cap on iron pipe set over P. B. M. 317. Eleva 621.75.

T. B. M. 1, R. B. Is top of water table 6 inches above platform, on southeast ner of Chicago, Milwaukee and St. Paul Railway depot at Green Island, Io Elevation, 607.14.

Base of rail in front of Chicago, Milwaukee and St. Paul Railway depot at G Island, Iowa. Elevation, 604.52.

B. M. 100000 of Chicago, Milwaukee and St. Paul Railway. Is railway s driven horizontally in blazed 10-inch ash tree standing on levee between rail track and west right of way fence of Chicago, Milwaukee and St. Paul Rail at south end of bridge No. 28 K which crosses Maquoketa River. B. M. is 2 above ground. Elevation, 605.67.

T. B. M. 2, R. B. Is head of vertical rivet in southeast corner of east (or ri end of iron bed plate under the north end of iron bridge No. 28 K over the Ma keta River and is 3.2 feet below top of rail. Elevation, 606.57.

STONE LINE 171 (6 MILES BELOW BELLEVUE, IOWA).

$\frac{171}{1}$. Tile and pipe one-half meter south and one-half meter west of the north corner of McCauley property, about 6 miles below Bellevue, Iowa, on Illinois sh opposite lower end of Island No. 254.

Elevation cap on pipe, 664.57. Bolt in tile, 660.57.

$\frac{171}{2}$. Tile and pipe 50 meters from shore, in wagon road along river, one- meter from east fence and 6 meters south of south fence along east and west wa road, about 100 meters below Mr. Degear's house.

Elevation cap on pipe, 626.74. Bolt in tile, 622.73.

$\frac{171}{3}$. Tile and pipe 15 meters from river bank, one-fourth mile above small is and opposite point just below Island No. 253. On sandy ridge in maple timbe meters northeast of slough 40 meters wide. To 10-inch maple 40°—6.7 meters 8-inch maple 14° 30′—6.1 meters; to 14-inch cottonwood 242° 30′—8.5 meters.

Elevation cap on pipe, 598.48. Bolt in tile, 594.48.

$\frac{171}{4}$. Tile and pipe back of B. M. $\frac{171}{3}$, 480 meters from river, 32 meters wes slough and 25 meters east of another slough, on narrow neck of land between sloughs. To 36-inch oak 205°—13.1 meters; to 36-inch elm 293° 30′—10.1 meters 8-inch cherry 50°—3.6 meters.

Elevation cap on pipe, 594.68. Bolt in tile, 590.68.

U. S. P. B. M. 315. Is on right bank, opposite Island No. 253, one-third below log house at Golden's woodyard, 56 feet back from top of bank and 2 below the fence on the lower side of clearing and upper side of woods which run about right angles to the river bank, 8 feet above a 10-inch ash tree, blazed, fa the bench, being copper bolt in tile set 3 feet underground. Elevation, 594.44.

U. S. P. B. M. 316. Is top of cap on iron pipe set over P. B. M. 315. Eleva 598.41.

U. S. P. B. M. 313. Is on right bank about 5¼ miles below Bellevue, Iowa, on so side of slough at foot of Island No. 250, 88 feet from northwest corner of Mr. Golden's log house, at the third from river of a row of four ash trees, being copper bolt in tile set 3 feet underground. Elevation, 595.72.

U. S. P. B. M. 314. Is top of cap on iron pipe set over P. B. M. 313. Elevation, 599.70.

T. B. M. 5, R. B. Is top of railway spike driven in top of east end of cap on south bent of bridge No. 36 K on Chicago, Milwaukee and St. Paul Railway, 13 feet north of Pleasant Creek Railway station. Elevation, 602.40.

T. B. M. 8, L. B. Is nail on south end of east abutment of Chicago, Burlington and Northern Railroad bridge No. 44, about 1 mile west of Hanover depot, just east of road crossing. Elevation, 625.60.

U. S. P. B. M. 311. Is on right bank 3¼ miles below Bellevue, Iowa, on the line of the Chicago, Milwaukee and St. Paul Railway, 177 feet below the lower side of C. A. Harrington's stone barn, 40 feet above the wooden drain under the track, at lower end of small cut, 33 feet east from center of track and 1¼ feet west from east right of way fence, being copper bolt in tile set 3 feet underground. Elevation, 602.36.

U. S. P. B. M. 312. Is top of cap on iron pipe over P. B. M. 311. Elevation, 606.36.

T. B. M. 331. Is on right bank 3¼ miles below Bellevue, Iowa, on line of Chicago, Milwaukee and St. Paul Railway track, 250 feet above C. A. Harrington's house, on southwest corner of stone culvert, 3 feet above south side and 3 inches back from the west end, marked "U. □ S.," being the highest point in square. Elevation, 607.14.

STONE LINE 172 (ONE-FOURTH MILE BELOW HEAD OF ISLAND NO. 249, ABOUT 2 MILES BELOW BELLEVUE, IOWA).

$\frac{172}{1}$. Tile and pipe in timber 15 meters west of large slough 595.7 meters back of B. M. $\frac{172}{2}$. Timber in vicinity of B. M. is nearly all birch. To 24-inch double maple 23°—2.4 meters; to 15-inch birch 332°—52 meters; to 10-inch birch 182°—3.1 meters.

Elevation cap on pipe, 593.83. Bolt in tile, 589.81.

$\frac{172}{2}$. Tile and pipe 40 meters from bank of slough in bunch of elms, about one-fourth mile below a point opposite the head of Island No. 249. To 18-inch birch 242°—13.5 meters; to 30-inch elm 67°—14.5 meters; to 24-inch elm 152°—20 meters.

Elevation cap on pipe, 596.76. Bolt in tile, 592.73.

$\frac{172}{3}$. Tile and pipe 1 meter west of west right of way fence of Chicago, Milwaukee and St. Paul Railway, 55 meters above bridge No. 40 K, about 60 meters above a wagon bridge. Wagon bridge is at foot of bluffs where wagon road turns from river and appears to go up bluffs.

Elevation cap on pipe, 615.61. Bolt in tile, 611.53.

T. B. M. 329. Is on right bank about one-fourth mile below bridge No. 42 K, one-third mile below mile post 142-19, on line of Chicago, Milwaukee and St. Paul Railway, 279 feet above sluiceway under track, 12 feet west from center of track on west side of ditch on natural outcropping of ledge of rock marked "U. □ S.," being highest point in square. Elevation, 612.45.

U. S. P. B. M. 309. Is on right bank 2 miles below Bellevue, Iowa, 558 feet above center of Chicago, Milwaukee and St. Paul Railway, bridge No. 42 K over Duck Creek, 148 feet above mile post 142-19, at upper side of highway crossing, at south side of fence running to cattle guard and 20 feet east from center of track, being copper bolt in tile set 3 feet under ground. Elevation, 611.90.

U. S. P. B. M. 310. Is top of cap on iron pipe over P. B. M. 309. Elevation, 615.88.

U. S. P. B. M. 308. Is on right bank at lower end of Bellevue, Iowa, on river bank, in first building above sawmill, a two-story stone store owned by M. G. Heiler, at its west front, second door from north end, marked "U. ⊙ S.," being top of copper bolt leaded vertically. Elevation, 617.59.

T. B. M. 326. Is at lower end of Bellevue, Iowa, on line of Chicago, Milwaukee and St. Paul Railway, on bridge No. 44 K over Mill Creek, between the flour mill and sawmill, on the north pier at its east end, marked "U. □ S.," being highest point in square. Elevation, 615.09.

High-water marks cut on door frame in east end of flour mill in lower part of Bellevue, Iowa, at creek. High-water 1866, elevation, 603.57; 1868, elevation, 604.02; 1870, elevation, 604.77; 1881, elevation, 605.84.

U. S. B. M. (old). Is in Bellevue, Iowa, at river shore, on Killburn & Co.'s warehouse, on projecting stone at the east end of south wall, just below the iron bolt plate, being the highest point in circle cut in stone. Elevation, 603.77.

U. S. P. B. M. 307. Is in Bellevue, Iowa, on southeast corner of Court and Second streets, on the front of stone store owned by John Baumann, on lower end of water table 2¼ feet above south corner, marked $\underset{\text{P. B. M.}}{\overset{\text{U. S.}}{\odot}}$, being top of copper bolt leaded vertically. Elevation, 626.03.

U. S. P. B. M. 305. Is in the upper part of Bellevue, Iowa, on west line of Fr street, in northeast corner of lot owned by Mrs. Booth, 2 feet south from north of lot and south side of a street, being copper bolt in tile set 3 feet under grou Elevation, 625.64.

U. S. P. B. M. 306. Is top of cap on iron pipe set over P. B. M. 305. Elevat 629.63.

T. B. M. 8, R. B. Is top of northeast corner of stone sill of lower window on side of waterworks pump-house at upper end of Bellevue, Iowa. Corner of si niched below and on each side of T. B. M. Elevation, 612.62.

STONE LINE 173 (UPPER END OF BELLEVUE, IOWA).

$\frac{173}{1}$. Tile and pipe about one-half mile from river, one-half meter from fence in wa road leading back from ferry landing opposite Bellevue, Iowa; 100 meters bey 100-foot wooden bridge across slough. To 10-inch birch 102°—16.7 meters.

Elevation cap on pipe, 601.07. Bolt in tile, 597.13.

$\frac{173}{2}$. Tile and pipe about 100 meters below mouth of slough opposite Belle Iowa. It is about 50 meters from shore and 50 meters north of fringe of timber fo ing south boundary of a very prominent cleared spot. Clearing is about 200 me wide and appears to extend back to bluffs. To 24-inch elm 49°—22.4 meters; to inch elm 166°—8.5 meters.

Elevation cap on pipe, 599.04. Bolt in tile, 595.03.

$\frac{173}{3}$. Tile and pipe on east line of north and south alley running between Fr and Second streets. Inside of fence on property of Mr. Mose Bean in upper en Bellevue. Mr. Bean's house is a large yellow frame facing Front street and one bl south of Harmony Park. To southwest corner of Bean's residence 338°—18.5 met

Elevation cap on pipe, 637.095. Bolt in tile, 633.085.

T. B. M. 10, L. B. Is highest point at east side and north end of solid rock ab ment of Chicago, Burlington and Northern Railroad bridge No. 48, over tunnel f lead mine in bluff. Elevation, 609.51.

U. S. P. B. M. 303. Is 1 mile above North Bellevue, Iowa, 40 feet back from hi water line on river bank and 45 feet north of bank of creek which is crossed by cago, Milwaukee and St. Paul Railway bridge No. 48 K, about 984 feet from railr and about 410 feet below large stone arch culvert under wagon road, and 36 feet so from another wagon road winding around south point of bluff, being copper bol tile set 3 feet under ground. Elevation, 598.50.

U. S. P. B. M. 304. Is top of cap on iron pipe set over P. B. M. 303. Elevati 602.47.

U. S. P. B. M. 302. Is 1 mile above North Bellevue, Iowa, on line of Chicago, waukee and St. Paul Railway, 1,279 feet below milepost 138-23, in the north a ment east end of bridge No. 48 K, on third course of stone from top, marked $\underset{P.}{\overset{U.}{\odot}}$ being top of copper bolt leaded vertically. Elevation, 633.26.

STONE LINE 174 (3 MILES ABOVE BELLEVUE, IOWA).

$\frac{174}{1}$. Tile and pipe in timber 863.5 meters back of B. M. $\frac{174}{2}$, at large band slough, 15 meters from bank and at intersection of slough with Yonkers Lake. 10-inch maple 4.8 meters; to 24-inch elm 174°—9 meters; to 30-inch double 253°—17.2 meters; to 30-inch elm 296°—6 meters.

Elevation cap on pipe, 598.69. Bolt in tile, 594.67.

$\frac{174}{2}$. Tile and pipe 30 meters from shore in timber, about 300 meters from hea Crooked Slough. About one-fourth mile above foot of Island No. 243. To 24-i elm 354°—4 meters; to 24-inch elm 134° 30′—8.5 meters; to 18-inch birch 270° 30 meters.

Elevation cap on pipe, 599.53. Bolt in tile, 595.53.

$\frac{174}{3}$. Tile and pipe one-half meter west of west right of way fence of Chicago, waukee and St. Paul Railway, on property belonging to Mr. Efferding. On top of foot railroad cut, about one-half mile above foot of Island No. 243. To 10-i black oak 197°—9.3 meters; to 18-inch black oak 56°—35.7 meters.

Elevation cap on pipe, 648.755. Bolt in tile, 644.725.

$\frac{174}{4}$. Tile and pipe one-fourth meter north of an east and west wire fence, on v high ridge, about three-fourths mile from river. A rocky point stands about o fourth mile north of B. M. B. M. is on property of John Weinert, 20 meters w of a gate, 100 meters west from jog in wire fence.

Elevation cap on pipe, 757.73. Bolt in tile, 753.70.

U. S. P. B. M. 300. Is on right bank behind Bellevue Slough, 262 feet from low-wa edge, 1½ miles below Smiths Station and 3 miles above North Bellevue, 1,900 f above Chicago, Milwaukee and St. Paul Railway bridge No. 50 K, and 150 feet bel stone culvert, on the right of way at the east fence, being copper bolt in tile s feet under ground. Elevation, 612.94.

U. S. P. B. M. 301. Is top of cap on iron pipe over P. B. M. 300. Elevation, 616.92.

U. S. P. B. M. 298. Is on right bank at the head of Bellevue Slough, three-fourths of a mile above Smiths Station on line of Chicago, Milwaukee and St. Paul Railway, 110 feet above bridge No. 56 K, 55 feet above lower line of A. M. Brown's house, 12 feet below the cattle guard on river side of track, 16 feet from center, on small bench of ground between cattle guard and gate leading down to river, being copper bolt in tile set 3 feet under ground. Elevation, 608.89.

U. S. P. B. M. 299. Is top of cap on iron pipe over P. B. M. 298. Elevation, 612.88.

T. B. M. 321. Is on right bank at point of bluff at head of Bellevue Slough at lower end of cut, in front of house owned by A. M. Brown, and 15 feet below the path running to this house, 125 feet above Chicago, Milwaukee and St. Paul Railway bridge No. 56 K at upper side of cattle guard, 12 feet west from center of track, on natural ledge of rock, marked "U. □ S.," being highest point in square. Elevation, 614.35.

Base of rail opposite depot at Aitken, Ill., on Chicago, Burlington and Northern Railroad. Elevation, 613.61.

Base of rail opposite depot at Aitken, Ill., on Chicago Great Western Railway. Elevation, 615.08.

STONE LINE 175 (HEAD OF STONE SLOUGH).

$\frac{175}{1}$. Tile and pipe on main shore 20 meters back of Fevre River, 1,182 meters from river bank, at foot of and on west side of high rocky embankment on Chicago Great Western Railway, 200 meters above depot at Aitken, Ill., 100 meters above switch post. To 24-inch maple 135°—12.7 meters.

Elevation cap on pipe 602.36. Bolt in tile, 598.35.

$\frac{175}{2}$. Tile and pipe in small open spot on Island No. 241, 60 meters from river bank and about 150 meters below head of island. To 36-inch elm 81°—19.5 meters; to 30-inch elm 31°—7 meters; to 30-inch cottonwood 261°—7.5 meters.

Elevation cap on pipe, 601.60. Bolt in tile, 597.58.

$\frac{175}{3}$. Tile and pipe one-half meter west of right of way fence of Chicago, Milwaukee and St. Paul Railway, opposite head of Stone Slough, 75 meters above two large bowlders, one inside and the other outside of right of way, 200 meters above end of railroad curve, 400 meters above a large trestle. To 12-inch oak 316°—14.8 meters; to 15-inch oak 22°—6.1 meters.

Elevation cap on pipe, 626.975. Bolt in tile, 622.955.

Base of rail opposite depot at Galena Junction, Ill., on Chicago, Burlington and Northern Railroad. Elevation on west side of depot, 617.48; on east side, 619.17.

Elevation at lock basin near mouth of Galena River: Highest part of west end of north wall, elevation 599.54; highest part of west end of south wall, elevation 600.11.

High-water mark of 1880 at east end of south face of lock-keeper's frame house at lock near mouth of Galena River. This mark is based on one made on post-office building at Galena, Ill., made at time of highest water during flood of 1880, and was established by a line of levels run from there by Mr. J. C. McIntyre, of the Rock Island, Ill., division. Elevation, 608.78.

United States gauge at Galena Junction, Ill., is fastened on north side of trestle work of draw pier of Chicago, Burlington and Northern Railroad bridge over Galena River. Elevation of zero, 588.38.

Railway gauge at Galena Junction, Ill., is alongside United States gauge mentioned above. Elevation of zero, 588.84.

T. B. M. 15, L. B. Is cross in center of black-painted spot with ring of white paint around it, on northeast corner of south pier of Illinois Central Railroad drawbridge over Galena River, on cap 1 foot from north side and 6 inches from east end. The mark had been made some time, but when connection was made with it no information as to its authorship could be obtained. Elevation, 612.93.

U. S. P. B. M. 296. Is 1¼ miles below Gordons Ferry, Iowa, about one-third mile below milepost 132–29, on a low ridge at upper side of coulée, 49 feet west from center of Chicago, Milwaukee and St. Paul Railway track, on right of way, at west fence, being copper bolt in tile set 3 feet underground. Elevation, 613.95.

U. S. P. B. M. 297. Is top of cap on iron pipe over P. B. M. 296. Elevation, 617.97.

T. B. M. 318. Is 1¼ miles below Gordons Ferry, Iowa, on line of Chicago, Milwaukee and St. Paul Railway, 396 feet below milepost 132–29 and 18 feet west from center of track, one-half foot above surface of ground, on flat rock, marked "U. □ S.," being highest point in square. Elevation, 617.93.

U. S. P. B. M. 294. Is at Gordons Ferry, Iowa, 250 feet below Chicago, Milwaukee and St. Paul Railway bridge No. 64 K, 215 feet below depot, 125 feet above lower head block of siding, 45 feet below lower side of stock yard, and 34 feet from center of track, on bluff side, being copper bolt in tile set 3 feet underground. Elevation, 621.07.

U. S. P. B. M. 295. Is top of cap on iron pipe over P. B. M. 294. Elevation, 625.

T. B. M. 315. Is about one-half mile above Gordons Ferry, Iowa, 1,875 feet bel Chicago, Milwaukee and St. Paul Railway Bridge No. 66 K, and 1,213 feet abo water tank, midway between two projecting points of bluff, 12 feet west from cent of track and 1½ feet above grade, on natural ledge of rock, marked "U. □ S.," bei highest point in square. Elevation, 618.84.

STONE LINE 176 (HEAD OF ISLAND NO. 238, 1 MILE ABOVE GORDONS FERRY).

$\frac{176}{1}$. Tile and pipe in pasture one-half meter west of west right of way fence Chicago Great Western Railway and Illinois Central Railroad tracks, 900 met from river, and 232 meters east of slough, 30 meters north of gate in fence at railro crossing, 60 meters north of railroad bridge No. 743 on Chicago Great Western Ra way, 70 meters below fence corner. To 14-inch white oak 320°—35.5 meters.

Elevation cap on pipe, 606.98. Bolt in tile, 602.97.

$\frac{176}{2}$. Tile and pipe in open ground 20 meters from river bank on Island No. 2 about 200 meters above head of Harris Slough. Three large cottonwood trees sta on river bank in front of B. M. To 24-inch cottonwood tree 354°—13 meters; 8-inch willow 252°—15 meters; to 10-inch maple 16°—9.5 meters.

Elevation cap on pipe, 598.84. Bolt in tile, 594.81.

$\frac{176}{3}$. Tile and pipe one-half mile above Gordons Ferry, Iowa, one-half met west of right of way fence of Chicago, Milwaukee and St. Paul Railway. On ben above railroad track, 10 meters from perpendicular rock bluff and about 150 met below a large bridge (No. 66 K) across creek. To 10-inch white birch 315°—9 mete to 30-inch cottonwood tree 102°—39 meters.

Elevation cap on pipe, 625.01. Bolt in tile, 621.01.

U. S. P. B. M. 292. Is about 1 mile above Gordons Ferry, Iowa, on line of Chica Milwaukee and St. Paul Railway, 250 feet above north end of bridge over Tete Mort Creek (No. 66 K), 210 feet below bridge No. 68 K and 875 feet below an old sto house west of track, 27 feet west from center of track, being a copper bolt in t set 3 feet underground. Elevation, 607.46.

U. S. P. B. M. 293. Is top of cap on iron pipe over P. B. M. 293. Elevation, 611.46.

T. B. M. 314. Is about 1 mile above Gordons Ferry, Iowa, on line of Chicago, M waukee and St. Paul Railway, 180 feet below sign, "Gordons Ferry, One Mile," south abutment, river end of bridge No. 68 K, on fourth course of stone from to on center of north end of inner stone, marked "U. □ S.," being highest point square. Elevation, 605.94.

T. B. M. 18, L. B. On Illinois Central Railroad bridge No. 753, over Sinsina Creek. On southwest corner of east pier, about 6 inches from side and end. Ele tion, 613.16.

U. S. P. B. M. 290. Is about 3 miles above Gordons Ferry, Iowa, opposite head Island No. 235, 125 feet below center of Chicago, Milwaukee and St. Paul Railw bridge No. 72 K, 43 feet west from center of track, on right of way, at fence, bei copper bolt in tile set 3 feet underground. Elevation, 611.17.

U. S. P. B. M. 291. Is top of cap on iron pipe over P. B. M. 290. Elevation, 615.

T. B. M. 312. Is on right bank opposite head of Island No. 235, 285 feet bel U. S. P. B. M. 290, 1,270 feet above milepost 128-33, 410 feet below Chicago, Milwau and St. Paul Railway bridge No. 72 K, at Snyder's wood yard, 12 feet west from cen of track, on lower end of very large inclined rock at a rocky point, marked "U. □ S being highest point in square. Elevation, 618.25.

STONE LINE 177 (NEAR CENTER OF ISLAND NO. 233, 9 MILES BELOW DUBUQUE, IOW

$\frac{177}{2}$. Tile and iron pipe on left bank, on side of bluff near top, about 300 met below large rock quarry, 1 meter east of fence running over bluff. Blazed tree 12-inch hickory 229° (mag.)—10 meters; 10-inch oak post 160° (mag.)—10 meters.

Elevation cap on pipe, 730.00. Bolt in tile, 726.04.

$\frac{177}{3}$. Tile and iron pipe on right bank, on right of way of Chicago, Milwaukee a St. Paul Railway, one-half meter from fence, opposite a point about 10 meters bel a post on roadbed marked 34-127, about 400 meters below railroad bridge No. 74 Blazed trees: 8-inch black oak 69°—5 meters; 10-inch white oak 331°—7 meters.

Elevation cap on pipe, 633.94. Bolt in tile, 629.96.

Base of rail opposite depot at Menominee, Ill. Elevation, Chicago, Burlingt and Northern Railroad, 614.38; Illinois Central Railroad, 615.88.

T. B. M. 311. Is on right bank about 1 mile below foot of Nine Mile Island, south abutment of Chicago, Milwaukee and St. Paul Railway bridge No. 76 K, we end, on second course of stone from top, marked "U. □ S.," being highest point square. Elevation, 618.31.

U. S. P. B. M. 288. Is on right bank opposite foot of Nine Mile Island, at wood yar 20 feet below road leading from there across Chicago, Milwaukee and St. Paul Ra way track up the bluff, 36 feet east from center of track and 2 feet west of east right of way fence, being copper bolt in tile set 3 feet underground. Elevation, 610.53.

U. S. P. B. M. 289. Is top of cap on iron pipe over P. B. M. 288. Elevation, 614.53.

T. B. M. 308. Is on right bank, about 1⅜ miles below Massey Station on line of Chicago, Milwaukee and St. Paul Railway on south abutment of bridge No. 78 K, west end, on second course of stone from top, on its southwest corner, marked "U. □ S.," being highest point in square. Elevation, 613.85.

STONE LINE 178 (NEAR CENTER OF NINE MILE ISLAND, 6 MILES BELOW DUBUQUE, IOWA).

$\frac{178^{a}}{2}$. Tile and iron pipe back from left bank on top of bluff, about 22 meters above railroad tracks and about 15 meters back from tracks, 50 meters below railroad bridge No. 102 on Chicago, Burlington and Northern Railroad, over small branch out of bluffs, one-half meter from board fence running over bluff. Ten-inch black oak 80°—19.6 meters; 10-inch black oak 333°—15 meters.

Elevation cap on pipe, 714.13. Bolt in tile, 710.18.

$\frac{178^{a}}{3}$. Tile and iron pipe on right bank, on right of way of Chicago, Milwaukee and St. Paul Railway, 50 meters below railroad station at Massey, about 50 meters toward river from foot of bluffs and one-half meter from farthest fence from river.

Elevation cap on pipe, 630.38. Bolt in tile, 626.43.

U. S. P. B. M. 286. Is on right bank, 6 miles below Dubuque, Iowa, on line of Chicago, Milwaukee and St. Paul Railway, at Shawondasee Club Grounds station, 76 feet below south end of platform and 86 feet above boundary fence between Paul Eiffer's and Frank Noel's lands, on west side of track, 47 feet from center, being copper bolt in tile set 3 feet underground. Elevation, 609.54.

U. S. P. B. M. 287. Is top of cap on iron pipe set over P. B. M. 286. Elevation, 613.54.

Old U. S. B. M. 24. Is on right bank, about 5 miles below Dubuque, Iowa, and one-half mile above Nine Mile Island, on south abutment of Chicago, Milwaukee and St. Paul Railway bridge No. 86 K, on river end of abutment, lowest course of stone, on northeast corner of step, marked "□," being highest point in square. Elevation, 597.81.

T. B. M. 304. Is on right bank, about 5 miles below Dubuque, Iowa, and one-half mile above Nine Mile Island, on south abutment of Chicago, Milwaukee and St. Paul Railway bridge No. 86 K, river end, on second course of stone below bridge seat, on northeast corner, marked "U. □ S.," being highest point in square. Elevation, 614.08.

T. B. M. 303. Is on right bank, about 1¼ miles above head of Nine Mile Island, on line of Chicago, Milwaukee and St. Paul Railway, directly opposite milepost 122–39, on bluff side, 9 feet from center of track, on natural ledge of rock, marked "U. □ S.," being highest point in square. Elevation, 621.83.

T. B. M. 302. Is on right bank, opposite foot of Island No. 228, 72 feet above the lower head block of switch at Cattes Siding, Chicago, Milwaukee and St. Paul Railway, 15 feet west from center of side track, in natural ledge of rock, marked "U. □ S.," being highest point in square. Elevation, 624.00.

T. B. M. 301. Is on right bank, about 3¼ miles below Dubuque, Iowa, on line of Chicago, Milwaukee and St. Paul Railway, 660 feet below milepost 121–40, 370 feet above upper head block of siding at Cattes and 295 feet below Creston Crossing, on lower side of coulée, 25 feet west from center of track, on natural ledge of rock, marked "U. □ S.," being highest point in square. Elevation, 623.58.

U. S. P. B. M. 284. Is on right bank, on upper side of coulée where T. B. M. 301 is located, 344 feet below milepost 121–40, 669 feet above upper head block of switch to Cattes Siding, 43 feet from center of track, on bluff side, in fence corner by gate, being copper bolt in tile set 3 feet underground. Elevation, 619.80.

U. S. P. B. M. 285. Is top of cap on iron pipe over P. B. M. 284. Elevation, 623.80.

STONE LINE 179 (3 MILES BELOW DUBUQUE, IOWA, AND ONE-FOURTH MILE ABOVE ISLAND NO. 228).

$\frac{179^{a}}{1}$. Tile and iron pipe on left bank at foot of bluffs on property of John A. Miller, one-half meter west of fence running along wagon road at foot of bluffs; 9 meters north of Miller's south line; about one-half mile above a large yellow barn, and about one-fourth mile below a rock barn, both at foot of bluffs.

Elevation cap on pipe, 634.31. Bolt in tile, 630.34.

$\frac{179^{a}}{2}$ = Ⓐ Lower Base. Tile and iron pipe on Illinois side, 3 meters east of west right-of-way fence of Illinois Central Railroad, on long curve 1¼ miles below East Dubuque, 25 meters above milepost 248–183, and 60 meters below farm crossing.

Elevation cap on pipe, 612.34. Bolt in tile, 608.38.

$\frac{4}{3}{}^{9}$. Tile and iron pipe on right bank, about 3 miles below Dubuque, Iowa, property of Joe Herod; 15 meters back from river bank, and one-half meter f right of way fence of railroad; 15 meters north of perpendicular rock cliff and ab 100 meters below railroad bridge No. 92 K. Six-inch white oak 101° (mag.) – meters.

Elevation cap on pipe, 619.27. Bolt in tile, 615.31.

Ⓐ Upper Base (near East Dubuque, Ill.). Elevation top of cap, 619.43. Bolt tile, 615.50.

T. B. M. 299. Is on right bank, about 1 mile below Dubuque, Iowa, at point of b on lower side of ravine through which the Illinois Central Railroad passes from river, 623 feet below the bridge on the Chicago, Milwaukee and St. Paul Railw track, 164 feet above house owned by R. Smith and 98 feet west from Chicago, waukee and St. Paul Railway track, on top of large flat rock, marked "U. □ being highest point in square. Elevation, 617.56.

U. S. P. B. M. 281. Is in southern extremity of Dubuque, Iowa, at the bluff eighth mile below the sawmill, directly opposite the end of runway to mill, feet above head block of sawmill siding, 26 feet west from center of siding, recess in face of rock bluff, marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$, being center of copper bolt leaded h zontally. Elevation, 619.24.

Old U. S. B. M. "b." Is in Dubuque, Iowa, on river front below the harbor, southeast corner of Houser & Linehan's boat store, 1¼ feet above the corner, on water table, in center of buttress, marked "⊙," being highest point of circl circle. Elevation, 613.09.

Old U. S. B. M. "a." Is in Dubuque, Iowa, at river front, below harbor, on Diamond Joe store, on upstream end of upstream doorsill, marked "□", being h est point of circle in square. Elevation, 614.23.

T. B. M. 297. Is in Dubuque, Iowa, on the Illinois Central Railroad depot, a north end, about in the center of east side of tower, in water table, marked "U. □ being highest point in square. Elevation, 615.09.

Base of rail opposite Chicago, Burlington and Northern Railroad depot at Dubuque, Ill. Elevation, 618.35.

Base of rail opposite Illinois Central Railroad depot at East Dubuque, Ill. El tion, 620.77.

Old U. S. B. M. "b." Is in East Dubuque, Ill., east of the Chicago, Burlington Northern Railroad track, under the end of the Dubuque highway bridge across Mississippi River, on the upstream foundation stone supporting the triangular t of said highway bridge, on upstream corner of stone, marked "B. ⊙ M.," being highest point of square within the old circle. Elevation, 621.29.

Old U. S. B. M. "a." Is in East Dubuque, Ill., on west abutment of the "j knife" draw of the Illinois Central Railroad over the Chicago, Burlington and No ern Railroad on its south end, on the southeast corner of top stone marked "B. ⊙ being highest point of square within the old circle. Elevation, 622.02.

Base of rail at East Dubuque end of Illinois Central Railroad bridge across ri Elevation, 627.04.

U. S. gauge at Dubuque. Is above draw pier of Illinois Central Railroad br on the breakwater crib work on inside of east timbering, being a staff gauge. vation of zero, 592.43.

The following elevations show the highest and lowest stages of the rive Dubuque since 1868, and are based on the records of the above-described gauge by the bridge tender:

High water, April 22, 1870, elevation, 613.26; high water, June 23, 1880, eleva 614.10; high water, October 25, 1881, elevation, 612.60; high water, May 13, elevation, 613.76; low water, January 3, 1890, elevation, 591.26; low water, Nove 28, 1895, elevation, 591.83.

U. S. P. B. M. 280. Is in Dubuque, Iowa, on west end and first pier of Illinois tral Railroad bridge across Mississippi River, at upper end of pier near its edge and about in center of bridge-seat stone, marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$, being top of copper leaded vertically. Elevation, 624.89.

T. B. M. 296. Is in Dubuque, Iowa, on north side of Fourth street, opp Chicago, Milwaukee and St. Paul Railway depot, on the Page House, 26¼ inches of southeast corner of building, on water table 6 inches in front of the west win marked "U. □ S.," being highest point in square. Elevation, 615.17.

City B. M. Is on Jess's store in Dubuque, Iowa, on southwest corner of First Main streets, near southeast corner of store, on north end of doorstep, being hig point in square. Elevation above city datum (by city engineer), 20.89. Eleva 615.76.

City B. M. 109. Is on the Julien House in Dubuque, Iowa, on north side of Se street, at east door of older part of the Julien House, on east end of doorstep, w is about 32 feet west of Iowa street, being highest point in square. Elevation above city datum (by city engineer), 24.46. Elevation, 619.41.

The Dubuque city engineer gives:

Low water 1854=Dubuque city datum elevation, 0.00; low water 1864=Dubuque city datum elevation, —3.33; high water 1870=Dubuque city datum elevation, 18.5; high water 1880=Dubuque city datum elevation, 19.5.

U. S. P. B. M. 279. Is in Dubuque, Iowa, at northeast corner of United States post-office building, 10 inches south of the north corner and 3 feet above the stone paving, marked $\overset{\text{U.S.}}{\underset{\text{P.B.M.}}{\odot}}$, being center of copper bolt leaded horizontally. Elevation, 651.62.

T. B. M. 295. Is in Dubuque, Iowa, on southwest corner of Elm and Ninth streets, on end of curb abutting against northeast corner of Chicago, St. Paul and Kansas City freight house, marked "U. □ S.," being highest point in square. Elevation, 614.33.

T. B. M. 294. Is in Dubuque, Iowa, at northwest corner of Fifteenth and Pine streets, at southeast corner of Iowa Coffin Company's warehouse, on top of foundation stone, being highest point in square. Elevation, 616.28.

U. S. P. B. M. 278. Is in Dubuque, Iowa, on south side of Iowa Coffin Company's warehouse, Fifteenth and Pine streets, on west end of first doorstep from Pine street, marked $\overset{\text{U.S.}}{\underset{\text{P.B.M.}}{\odot}}$, being top of copper bolt leaded vertically. Elevation, 616.41.

STONE LINE 180 (ABOUT THREE-FOURTHS MILE ABOVE RAILROAD BRIDGE OVER RIVER AT DUBUQUE, IOWA).

$\frac{180}{1}$. Tile and iron pipe on left bank on right of way of Chicago, Burlington and Northern Railroad along fence; about three-fourths mile above Dubuque Railroad bridge, and 75 meters above a two-story brick house which stands on right of way.

Elevation cap on pipe, 636.94. Bolt in tile, 632.99.

$\frac{180}{2}$. Tile and iron pipe on right bank below shops of Chicago, Milwaukee and St. Paul Railway; one-half meter north of southeast corner of small stock yards which are just south of roundhouse of Chicago, Milwaukee and St. Paul Railway. Bench mark is about 50 meters southeast of roundhouse and 25 meters back from bank of slough. Southeast corner of pump house chimney of Chicago, Milwaukee and St. Paul Railway, 139° (mag.)—42.8 meters; southeast corner of tin shop, 203° (mag.)—47.8 meters.

Elevation cap on pipe, 618.265. Bolt in tile, 614.265.

T. B. M. 293. Is in the upper part of Dubuque, Iowa, on line of Chicago, Milwaukee and St. Paul Railway, at northwest corner of their freight-car repair shop, on southwest corner of foundation stone, marked "U. □ S.," being highest point in square. Elevation, 617.87.

T. B. M. 24 L. B. Is highest point near center of large detached rock at north end of Chicago, Burlington and Northern Railroad bridge No. 65, on east side of track and about 3½ feet from west face of rock. Elevation, 620.76.

U. S. P. B. M. 276. Is at Eagle Point, Iowa, one-fifth mile below Dubuque Woodenware Company's works, on line of Chicago, Milwaukee and St. Paul Railway, 2,181 feet above milepost 115–46, 394 feet above bridge No. 114 K, and 267 feet below bridge No. 114½ K over sewer, on the upper end of mound built up from earth excavation from opposite side of track, 1½ feet west from east fence and 13½ feet from center of track, being copper bolt in tile set 3 feet under ground. Elevation, 614.80.

U. S. P. B. M. 277. Is top of cap on iron pipe over P. B. M. 276. Elevation, 618.80.

U. S. P. B. M. 275. Is at Eagle Point, Iowa, on main building of Dubuque Woodenware Company, on river bank, in foundation on south side, 1.8 feet from west corner and 2.1 feet above ground, marked $\overset{\text{U.S.}}{\underset{\text{P.B.M.}}{\odot}}$, being center of copper bolt leaded horizontally. Elevation, 612.66.

T. B. M. 291. Is at Eagle Point, Iowa, on Dubuque Woodenware Company's drying house, east of the railroad tracks, on top of stone foundation, 10 feet from west side, on lower side of building, marked "U. □ S.," being highest point in square. Elevation, 615.65.

Old U. S. B. M. 23. Is at Eagle Point, Iowa, above ferry landing, at prominent point of river bank covered with large rocks, on southwest part of very large triangular-shaped rock lying at the water's edge, being highest point in lower part of letter "B" cut on the rock. Elevation, 601.31.

T. B. M. 289. Is on right bank, about 1½ miles above Eagle Point, Iowa, one-fourth mile below milepost 113–48, midway between two small wooden box culverts, 20 feet west of center of railway track, on natural ledge of rock, marked "U. □ S.," being highest point in square. Elevation, 625.14.

STONE LINE 181 (AT UPPER END OF EAGLE BLUFFS, 3 MILES ABOVE DUBUQU IOWA).

$\frac{181}{1}$. Tile and iron pipe on property of Chris. Brant, along right of way fence Chicago, Burlington and Northern Railroad. This fence is nearest one to river; meters above end of switch, and 150 meters below milepost on roadbed marked 24 190; a two-story frame house stands about 200 meters above B. M., and at foot bluffs in draw.

Elevation cap on pipe, 616.66. Bolt in tile, 612.70.

$\frac{181}{2}$. Tile and iron pipe on left bank, 25 meters back from river; about 150 met below buildings in park. 18-inch ash, 63° (mag.)—17.1 meters; 18-inch pin o 344° (mag.)—6.4 meters; 18-inch ash, 114° (mag.)—18.8 meters.

Elevation cap on pipe, 609.42. Bolt in tile, 605.47.

$\frac{181}{3}$. Tile and iron pipe on right bank at foot of bluffs, 8 meters toward bluffs fr center of Chicago, Milwaukee and St. Paul Railway track; 125 meters above a sig board reading "Slow, 6 miles per hour;" about 100 meters below a point oppos ferry landing on left bank.

Elevation cap on pipe, 625.09. Bolt in tile, 621.14.

U. S. P. B. M. 273. Is on right bank, 2.3 miles above Eagle Point, Iowa, 436 f below Chicago, Milwaukee and St. Paul Railway bridge No. 122 K, 896 feet bel railroad platform, in front of James Cushing's house, 23 feet east from center of tra 58 feet south of small stone culvert, on right of way, being copper bolt in tile se feet under ground. Elevation, 615.08.

U. S. P. B. M. 274. Is top of cap on iron pipe over P. B. M. 273. Elevation, 619.

T. B. M. 287. Is 2.3 miles above Eagle Point, Iowa, 1,569 feet below milepost 112- 1,161 feet above bridge No. 120 K, 377 feet below bridge No. 122 K, 836 feet below t small railroad platform in front of James Cushing's house, 6 feet west from center track, on upper end of capstone of small stone culvert marked "U. □ S.," being hig est point in square. Elevation, 618.20.

T. B. M. 26, L. B. Is nail in top timber of west abutment, near south end, Chicago, Burlington and Northern Railroad bridge No. 72, a little above milep 191. Elevation, 616.28.

T. B. M. 27, L. B. Is nail in top timber of south abutment, near west end, Chicago, Burlington and Northern Railroad bridge No. 76. Elevation, 617.84.

Base of rail opposite Chicago, Milwaukee and St. Paul Railway depot at Edm Siding, Iowa. Elevation, 621.53.

U. S. P. B. M. 271. Is on right of way of Chicago, Milwaukee and St. Paul Ra way, 6½ miles above Dubuque, Iowa, 531 feet below south end of bridge No. 124 over little Maquoketa River, very close to line produced of east side of said brid three-fourths of a mile above Edmore Siding, on west side of track, 2 feet from fen opposite center of railroad curve, being copper bolt in tile set 3 feet under groun Elevation, 619.10.

U. S. P. B. M. 272. Is top of cap on iron pipe over P. B. M. 271. Elevation, 623.

STONE LINE 182 (ABOUT 1 MILE ABOVE SINOPE, WIS., AND HALFWAY BETWE HEAD AND FOOT OF MAQUOKETA SLOUGH).

$\frac{182}{1}$. Tile and iron pipe on left bank, about three-fourths mile above Sinope, Wi at foot of bluffs; 4 meters toward bluffs from center of Chicago, Burlington a Northern Railroad tracks; 194 meters below a railroad bridge, and 79 meters bel milepost marked 193–238.

Elevation cap on pipe, 621.44. Bolt in tile, 617.54.

$\frac{182}{2}$. Tile and iron pipe on left bank of Island No. 217, 10 meters from river ban and about one-fourth mile below head of island. Blazed trees: 18-inch maple, 4 (mag.)—6.4 meters; 12-inch maple, 109° (mag.)—8.7 meters.

Elevation cap on pipe, 610.79. Bolt in tile, 606.82.

$\frac{182}{3}$. Tile and iron pipe on right bank in right of way of Chicago, Milwaukee a St. Paul Railway, one-half meter from fence, at foot of a bald bluff; about 150 mete above railroad station at Zollicoffer Lake; 25 meters above upper end of curve station. Blazed trees: 14-inch hard maple, 146° (mag.)—49.3 meters; 14-inch bla oak, 11° (mag.)—36.5 meters.

Elevation cap on pipe, 632.93. Bolt in tile, 630.34.

T. B. M. 283. Is on right bank, about 1¼ miles above Little Maquoketa bridge line of Chicago, Milwaukee and St. Paul Railway, two-thirds of a mile above Zol coffer Lake, and 1,076 feet above milepost 109–52, 12 feet west of track, on large f rock inside bank, inclining about 30° to the horizon, marked "U. □ S.," being hig est point in square. Elevation, 623.39.

T. B. M. 29, L. B. Is nail in timber at south end of Chicago, Burlington and Nort ern Railroad bridge No. 80, about 2 feet from west end of timber. Elevation, 620.2

T. B. M. 30, L. B. Is on north corner of southeast abutment of Chicago, Burlingt and Northern Railroad bridge No. 81, over Platte River. On top of cap just where it begins to bevel. Elevation, 621.89.

U. S. P. B. M. 269. Is on right bank, 2¼ miles above Little Maquoketa River, on line of Chicago, Milwaukee and St. Paul Railway, and 3¼ miles below Spechts Ferry, Iowa, 912 feet below milepost 108–53, opposite lower end of bridge No. 128 K, over Leisures Creek, 49 feet east from center of track, on right of way in corner of fence formed by main fence and wing fence to bridge No. 128 K, in slope of bluff, being copper bolt in tile set 3 feet underground. Elevation, 624.89.

U. S. P. B. M. 270. Is top of cap on iron pipe over P. B. M. 269. Elevation, 628.92.

T. B. M. 31, L. B. Is nail in top of east abutment of Chicago, Burlington and Northern Railroad bridge No. 82, about 2 feet from south end of timber, 2 feet below track. Elevation, 618.57.

T. B. M. 32, L. B. Is nail in top of east abutment of Chicago, Burlington and Northern Railroad bridge No. 83, about 1¼ feet from south end and on west side of timber. Elevation, 620.02.

U. S. P. B M. 267. Is on right bank, about 1¼ miles below Spechts Ferry, Iowa, at Parsons Bar, on extreme point of bluff between rock quarry and railroad bridge No. 134 K, about 300 feet above the bridge, 25 feet south from center of track, being copper bolt in tile set 3 feet underground. Elevation, 616.38.

U. S. P. B. M. 268. Is top of cap on iron pipe over P. B. M. 267. Elevation, 620.39.

STONE LINE 183 (ABOUT 1¼ MILES BELOW SPECHTS FERRY, AND 1 MILE BELOW HEAD OF ISLAND NO. 213).

$\frac{183}{1}$. Tile and iron pipe outside of right of way of Chicago, Burlington and Northern Railroad at jog in fence just below small gully, 130 meters above milepost 234-197; about 100 meters below a point opposite small log house at foot of bluffs.

Elevation cap on pipe, 624.79. Bolt in tile, 620.82.

$\frac{183}{2}$. Tile and iron pipe on right bank of Island No. 213, and about three-fourths mile below its head; 15 meters back from bank of river on high ground, opposite rock quarry on right bank. Trees: 30-inch elm 350° (mag.)—5.7 meters; 24-inch elm 72° (mag.)—9.0 meters; 30-inch elm 122° (mag.)—9.4 meters.

Elevation cap on pipe, 609.68. Bolt in tile, 605.71.

$\frac{183}{3}$. Tile and iron pipe one-half meter west of east right of way fence Chicago, Milwaukee and St. Paul Railway, about 1¼ miles below Spechts Ferry, between tenth and eleventh telegraph poles, below a signboard which reads "Slow to 6 miles an hour;" 55 meters above wagon road crossing at rock quarry, 175 meters above railroad bridge No. 138 K.

Elevation cap on pipe, 624.11. Bolt in tile, 620.16.

T. B. M. 33, L. B. Is nail in top of east abutment of Chicago, Burlington and Northern Railroad bridge No. 81, about 1 foot from south end of timber. Elevation, 620.84.

U. S. P. B. M. 265. Is at Spechts Ferry, Iowa, 354 feet below center of Chicago, Milwaukee and St. Paul Railway depot, 164 feet below bridge No. 140 K, 174 feet below lower side of stone milk house, 1 foot above fence forming west side of railroad cattle pen, on bluff side of track, 37 feet from center, being copper bolt in tile set 3 feet underground. Elevation, 618.22.

U. S. P. B. M. 266. Is top of cap on iron pipe over P. B. M. 265. Elevation, 622.22.

Old U. S. P. B. M. No. 30, on stone step. Is at Spechts Ferry, Iowa, on upper stone doorstep to Specht's stone house, downstream end, front edge, marked "⊙," being highest point in upper portion of circle. Elevation, 622.26.

Old U. S. B. M. "a." Is at Spechts Ferry, Iowa, at northeast corner of Specht's house, on the water table, but a few inches above the corner, marked "B. ⊙ M.," being highest point on front segment. Elevation, 622.74.

Base of rail opposite Chicago, Burlington and Northern Railroad depot at Potosi, Wis. Elevation, 622.19.

T. B. M. 35, L. B. Is nail in west abutment of Chicago, Burlington and Northern Railroad bridge No. 87, just west of Potosi depot, on south end of timber. Elevation, 620.86.

Base of rail opposite Chicago, Milwaukee and St. Paul Railway depot at Spechts Ferry, Iowa. Elevation, 620.61.

STONE LINE 184 (AT ISLAND NO. 209, 1¼ MILES ABOVE SPECHTS FERRY).

$\frac{184}{1}$. Tile and iron pipe in right of way of Chicago, Burlington and Northern Railroad along nearest fence to river; 175 meters below iron railroad bridge over Grant River; 42 meters below small railroad bridge; 75 meters above small frame house.

Elevation cap on pipe, 621.40. Bolt in tile, 617.45.

$\frac{184}{2}$. Tile and iron pipe on left bank, opposite lower end of small island at upper end of Island No. 209; stone line passes about 25 meters below head of Is No. 209; bench mark is 15 meters back from bank of river, and just behind s patch of willows. Blazed trees: 30-inch elm 111° (mag.)—18.9 meters; 30-inch 185° (mag.)—10.8 meters; 30-inch soft maple 288° (mag.)—15.3 meters.

Elevation cap on pipe, 612.21. Bolt in tile, 608.28.

$\frac{184}{3}$ = U. S. P. B. M. 263. Tile and iron pipe on right of way of Chicago, Milwa and St. Paul Railway, at fence at upper end of small picnic grounds, 25 m below end of bridge No. 148 K; bench mark is at Frenchtown Landing, Iowa.

Elevation cap on pipe, 621.69. Bolt in tile, 617.69.

U. S. P. B. M. 262. Is on right bank in front of Island No. 207, on line of Chi Milwaukee and St. Paul Railway, 919 feet above milepost 102–59, and 79 feet a section post 10–11, on west abutment of bridge No. 156 K, at its north end, or fourth stone step from top, and 3 inches from the end face of the third step, 9 in back from the east face, marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$, being top of copper bolt leaded vertic

Elevation, 622.43.

U. S. P. B. M. 260. Is on right bank, at Finley Landing, on line of Chicago, waukee and St. Paul Railway, 649 feet below milepost 101–60 and 180 feet a bridge No. 162 K, on right of way, 2 feet from south fence and 38 feet from cent track, being copper bolt in tile set 3 feet underground. Elevation, 625.68.

U. S. P. B. M. 261. Is top of cap on iron pipe over P. B. M 260. Elevation, 629.6

STONE LINE 185 (ABOUT THREE-FOURTHS MILE ABOVE FINLEY LANDING, IOW

$\frac{185}{1}$. Tile and iron pipe on right of way of Chicago, Burlington and Northern road, 100 meters above upper end of railroad bridge at foot of bluffs, one-half r from fence, 10 meters above a small log house, and 10 meters below milepost 204

Elevation cap on pipe, 625.81. Bolt in tile, 621.88.

$\frac{185}{2}$. Tile and iron pipe on Island No. 203; on lower end of island, 20 meters river bank, about opposite foot of Island No. 204; stone line crosses about cent Island No. 204. Blazed trees: 12-inch ash 124° (mag.)—3.9 meters; 24-inch el (mag.)—11.4 meters; 20-inch elm 164° (mag.)—12.9 meters.

Elevation cap on pipe, 613.06. Bolt in tile, 609.12.

$\frac{185}{3}$ = Ⓐ Rumpel. Tile and pipe on Iowa side; on south side of Chicago, Milwa and St. Paul Railway track, 6½ meters north of south right of way fence; on pr nent high ridge running out from bluff opposite head of first towhead below fo Hurricane Island. Station is about 6 meters from and 4½ meters higher than road tracks.

Elevation cap on pipe, 648.06. Bolt in tile, 644.10.

T. B. M. 38, L. B. Is nail in top of east abutment of Chicago, Burlington and N ern Railroad bridge No. 100, about 1¼ feet from south end. Elevation, 623.50.

T. B. M. 273. Is on right bank, 2½ miles below Waupeton, Iowa, and 1½ below Cameron, Iowa, on line of Chicago, Milwaukee and Saint Paul Railway, feet above milepost 100–61, about 100 feet below very large and conspicuous pie ledge covered with vines lying on the bluff side of the track, on bowlder ma "U. □ S.", being highest point in square. Elevation, 633.26.

Base of rail opposite Chicago, Burlington and Northern Railroad depot at Mc ney, Wis. Elevation, 623.97.

T. B. M. 12, R. B. Is spike in top and at river side of twenty-fourth tie (on bent) from upstream end of Chicago, Milwaukee and Saint Paul Railway b No. 164 K. Elevation, 628.15.

T. B. M. 13, R. B. Is nail driven horizontally 6 inches above ground in nort corner of telegraph office at Cameron, Iowa, on Chicago, Milwaukee and Saint Railway, 1 mile below Waupeton, Iowa. Elevation, 629.28.

Base of rail opposite telegraph office at Cameron, Iowa, on Chicago, Milwauke Saint Paul Railway. Elevation, 627.80.

Ⓐ Waupeton. Elevation top of bolt, 640.51.

STONE LINE 186 (ABOUT ONE-FOURTH MILE BELOW WAUPETON, IOWA).

$\frac{186}{1}$. Tile and iron pipe at foot of bluffs one-half meter from right of way fen Chicago, Burlington and Northern Railroad, 5 meters above upper end of rail bridge, 200 meters below milepost 224–207.

Elevation cap on pipe, 632.03. Bolt in tile, 628.09.

$\frac{186}{2}$. Tile and iron pipe on left bank, at edge of willows, and about 30 meters from river bank, on high ridge about 100 meters below upper end of willows; between $\frac{186}{3}$ and $\frac{186}{2}$ crosses Island No. 201 about 200 meters above its foot. Bl trees: 30-inch elm 210° (mag.)—8.9 meters; 12-inch white oak 282° (mag.) meters; 15-inch cottonwood 340° (mag.)—9.0 meters.

Elevation cap on pipe, 613.90. Bolt in tile, 609.95.

$\frac{6}{186}$=P. B. M. No. 258-259. Copper bolt in tile and iron pipe, 260 meters below Waupeton, Iowa, 187 meters below railroad bridge No. 172, on the north face of bluff at the point where it begins to curve to the south, 11 meters south from the center of the Chicago, Milwaukee and St. Paul Railway track, and 0.6 meter south from right of way fence.

Elevation cap on pipe, 626.65. Bolt in tile, 622.66.

Base of rail opposite Chicago, Milwaukee and St. Paul Railway depot at Waupeton, Iowa. Elevation, 630.79.

T. B. M. 270. Is on right bank, 1,171 feet above Chicago, Milwaukee and St. Paul Railway depot at Waupeton, Iowa, 420 feet below milepost 97-64, 264 feet above bridge No. 174 K, on bluff side of track, 10 feet from center on natural ledge of rock, about level with grade, marked "U. □ S.", being highest point in square. Elevation, 633.12.

T. B. M. 269. Is on right bank, 1¼ miles above Waupeton, Iowa, on line of Chicago, Milwaukee and St. Paul Railway, 593 feet below milepost 96-65, 377 feet above bridge No. 180 K, and just below a prominent ledge of white rock, on bluff side of track, 10 feet from center, and about 500 feet below bridge No. 182 K, on ledge of rock 2 feet above grade, marked "U. □ S.", being highest point in square. Elevation, 636.26.

U. S. P. B. M. 256. Is on right bank, 1½ miles above Waupeton, Iowa, 1,739 feet above milepost 96-65, 122 feet above Chicago, Milwaukee and St. Paul Railway bridge No. 186 K, over Dry Hollow, on bluff side of track, 16½ feet from center, just outside right of way fence, being copper bolt in tile set 3 feet underground. Elevation, 630.60.

U. S. P. B. M. 257. Is top of cap on iron pipe over P. B. M. 256. Elevation, 634.60.

T. B. M. 267. Is on right bank, 2 miles below Buena Vista, Iowa, 1,575 feet below section post 11-12, 1,411 feet below bridge No. 188 K, 775 feet above bridge No. 186 K, on line of Chicago, Milwaukee and St. Paul Railway, 10 feet south from center, on ledge of rock, marked "U. □ S.", being highest point in square. Elevation, 634.52.

T. B. M. 265. Is on right bank, three-fourths of a mile below Buena Vista, Iowa, 1,840 feet below milepost 94-67, and 590 feet below bridge No. 194 K, on bluff side of track, 15 feet from center on an embedded bowlder, marked "U. □ S.", being highest point in square. Elevation, 634.99.

STONE LINE 187 (ABOUT ONE-HALF MILE BELOW BUENA VISTA, IOWA).

$\frac{1}{187}$. Tile and iron pipe, on right of way of Chicago, Burlington and Northern Railroad, 1 meter from fence; on side of bluff immediately behind a large bowlder which lies near track; 200 meters below railroad bridge No. 112, and about one-half mile below milepost 221-210.

Elevation cap on pipe, 646.30. Bolt in tile, 642.35.

$\frac{2}{187}$. Tile and iron pipe on left bank 15 meters back from bank of slough; in scattering elms about 500 meters above foot of willow-covered island. This island is separated from left bank of river by small slough 25 meters wide. Blazed trees: 24-inch elm 258° (mag.)—17.3 meters; 20 inch elm 62° (mag.)—7.4 meters; 24-inch elm 109° (mag.)—16.7 meters.

Elevation cap on pipe, 616.68. Bolt in tile, 612.73.

$\frac{3}{187}$. Tile and iron pipe on right of way of Chicago, Milwaukee and St. Paul Railway, about 25 meters below lower end of railroad bridge No. 194; about 7 meters from center of track toward bluffs; about one-half mile below Buena Vista, Iowa.

Elevation cap on pipe, 635.57. Bolt in tile, 631.62.

Base of rail opposite Chicago, Milwaukee and St. Paul Railway depot at Buena Vista, Iowa. Elevation, 632.14.

U. S. P. B. M. 255. Is at Buena Vista, Iowa, at southeast corner of R. & E. Meuth's general store, 6 inches from south face and 4.3 feet above ground, in wall marked $\overset{\text{U.S.}}{\underset{\text{P.B.M.}}{\odot}}$, being center of copper bolt leaded horizontally. Elevation, 634.34.

T. B. M. 264. Is at Buena Vista, Iowa, 82 feet above depot and 35 feet above road crossing, on bluff side of track, 9 feet from center, about 2½ feet above grade, on ledge of rock marked "U. □ S.", being highest point in square. Elevation, 634.02.

T. B. M. 42, L. B. Is nail in top of west abutment of Chicago, Burlington and Northern Railroad bridge No. 113, about 6 inches from south end and on east side of timber. T. B. M. about 2 feet below track. This bridge is just east of milepost 210. Elevation, 625.39.

T. B. M. 262. Is on right bank opposite the foot of Island No. 196, about 1 mile above Buena Vista, Iowa, and 2,986 feet above milepost 93-68, 15 feet toward bluff from center of Chicago, Milwaukee and St. Paul Railway track, on upper one of three large and prominent pieces of rock lying but a few feet from each other, marked "U. □ S.", being highest point in square. Elevation, 632.51.

T. B. M. 44, L. B. Is nail in top of east abutment of Chicago, Burlington and

Northern Railroad bridge No. 114, about 6 inches from south end and at west sid timber. T. B. M. is about 2 feet below track. Elevation, 637.55.

◬ East Base (near Cassville, Wis.). Elevation top of cap, 635.75. Bolt in 631.80.

STONE LINE 188 (ABOUT ONE-HALF MILE BELOW CASSVILLE, WIS.).

$\frac{188}{2}$ = ◬ West Base. Tile and iron pipe on Wisconsin side at west end of Cass Base; 1½ meters, north of south right of way fence of Chicago, Burlington Northern Railroad; 50 meters below coal chute, and 1 meter south of prolonged of south rail of tangent.

Elevation cap on pipe, 626.97. Bolt in tile, 622.99.

$\frac{188}{3}$. Tile and iron pipe on small island opposite a pickle factory; 45 meters from bank of river, and 30 meters from slough at head of island; in small cle space in willows. Blazed trees: 24-inch willow 231° (mag.)—19.9 meters; 15- maple 132° (mag.)—11.4 meters; 18-inch willow 32° (mag.)—11.1 meters.

Elevation cap on pipe, 614.36. Bolt in tile, 610.40.

$\frac{188}{4}$ = P. B. M. 253-254. Tile and iron pipe on line of Chicago, Milwaukee and Paul Railway track, 2⅜ miles above Buena Vista, Iowa; 16 meters below cent bridge No. 204 K, Chicago, Milwaukee and St. Paul Railway; at fence on bluff 11 meters from center of track.

Elevation cap on pipe, 627.94. Bolt in tile, 623.94.

Base of rail opposite Chicago, Burlington and Northern Railroad depot at Cassv Wis. Elevation, 626.94.

T. B. M. 46, L. B. Is nail in top of west abutment of Chicago, Burlington Northern Railroad bridge No. 117, just below milepost 214. About 18 inches south end and on east side of timber. T. B. M. is about 2 feet below track. El tion, 625.29.

T. B. M. 258. Is on right bank, on line of Chicago, Milwaukee and St. Paul way, 1,689 feet below depot at Turkey River Junction, 1,660 feet above mile 90, and 50 feet above very large and prominent bowlder on west side of track, 328 feet above farmhouse at point of woods on river side of track, 15 feet wes center, on ledge of rock, marked "U. □ S.," being highest point in square. El tion, 629.95.

Base of rail opposite Chicago, Milwaukee and St. Paul Railway depot, at Tu River Junction, Iowa. Elevation, 628.49.

U. S. P. B. M. 252. Is at Turkey River Junction, Iowa, 1,148 feet above depo upper end of Chicago, Milwaukee and St. Paul Railway bridge No. 212, Turkey River, on west end of pier, 14 inches east from extreme point of roun capstone, marked $\overset{\text{U.S.}}{\underset{\text{P. B. M.}}{\odot}}$, being top of copper bolt leaded vertically. Elevat 623.33.

T. B. M. 257. Is on same pier of Turkey River bridge as P. B. M. 252, 9 feet west end and 7 inches from its north face, marked "U. □ S.," being highest poi square. Elevation, 623.32.

U. S. P. B. M. 251. Is on line of Chicago, Milwaukee and St. Paul Rail 1,552 feet above Turkey River bridge, 118 feet above cattle guard; and 249 feet b sign "Turkey River Junction, stop", 13 feet west of center of track and about 2 above grade, in ledge of rock marked $\overset{\text{U.S.}}{\underset{\text{P. B. M.}}{\odot}}$ on its face, being center of copper leaded horizontally. Elevation, 633.24.

T. B. M. 256. Is 23 feet above P. B. M. 251, 8 feet west from center of track, a 2 feet above grade, on natural ledge of rock, marked "U.□S." on its face, b highest point in square. Elevation, 631.52.

T. B. M. 48, L. B. Is nail in top of west abutment of Chicago, Burlington Northern Railroad bridge No. 118, about one-fourth mile above milepost 215. A 18 inches from south end and on east side of timber. T. B. M. is about 2 feet b track. Elevation, 626.94.

STONE LINE 189 (ABOUT 2½ MILES ABOVE CASSVILLE, WIS., NEAR HEAD OF ISL NO. 192).

$\frac{189}{1}$. Tile and iron pipe about 2½ miles above Cassville, Wis., on side of bl meter south of north fence along wagon road; about one-half mile above rock b and 50 meters north of Chicago, Burlington and Northern Railroad track; 50 me above a whistling post, and 10 meters below a small honey-locust tree which st along fence.

Elevation cap on pipe, 652.93. Bolt in tile, 648.98.

$\frac{189}{2}$. Tile and iron pipe on Island No. 189, about 400 meters above its foot; 75 m from right bank of Cassville Slough; about 100 meters below mouth of small sl which empties into Cassville Slough; on small clearing on ridge. Blazed trees: 12-inch maple 297° (mag.)—11.9 meters; 18-inch elm 40° (mag.)—5.4 meters; 36-inch elm 145° (mag.)—21.6 meters.

Elevation cap on pipe, 615.81. Bolt in tile, 611.85.

$\frac{189}{3}$. Tile and iron pipe on right bank of Guttenberg Channel, about opposite a point one-half mile above foot of Island No. 189; 50 meters below head of small slough and 10 meters back from bank of river. Blazed trees: 24-inch elm 115° (mag.)—10 meters; 18-inch elm 237° (mag.)—8.7 meters; 15-inch cottonwood 327° (mag.)—8 meters; 24-inch double maple 49° (mag.)—8.6 meters.

Elevation cap on pipe, 614.52. Bolt in tile, 610.57.

$\frac{189}{4}$. Tile and iron pipe about one-half mile above Turkey River Station; on right of way of Chicago, Milwaukee and St. Paul Railway, one-half meter from north fence; 8½ rail lengths above a sign TURKEY RIVER STOP JUNCTION.. Blazed tree: 12-inch ash—14 meters.

Elevation cap on pipe, 617.81. Bolt in tile, 613.84.

T. B. M. 15, R. B. Is top of extreme point toward river of horizontal rock 11 feet from center of Chicago, Milwaukee and St. Paul Railway track, on bluff side; 30 feet downstream from signboard "Station 1 mile," and 24 feet upstream from milepost 88-73; 1 mile above Turkey River, and at bend of slough where it leaves bluffs at upper end of Turkey River bottom. T. B. M. is 5 feet above track. Elevation, 642.56.

T. B. M. 49, L. B. Is nail in top of north abutment of Chicago, Burlington and Northern Railroad bridge No. 119, in center of timber and about 6 inches from west end, about 2 feet below track. Elevation. 626.55.

T. B. M. 254. Is 1¾ miles above point of bluff at north side of Turkey River, on line of Chicago, Milwaukee and St. Paul Railway, 331 feet below milepost 87–74, 12 feet west of center of track, on ledge of rock, marked "U. □ S.," being highest point in square. Elevation, 637.53.

T. B. M. 16, R. B. Is top of southeast corner of river end of west cap on bridge No. 222 K, about 2¼ miles above Turkey River bridge, and just above where channel leaves foot of bluffs to pass north of island. Elevation, 633.13.

T. B. M. 253. Is on right bank, about 3 miles below Guttenberg, Iowa, and 3¼ miles above point of bluff at railroad, on north side of Turkey River, on bridge No. 236, north abutment, east end, 1 foot from end of abutment and 6 inches from its south face, marked "U. □ S.," being highest point in square. Elevation, 629.06.

STONE LINE 190 (ABOUT 3 MILES BELOW GUTTENBERG, IOWA).

$\frac{190}{2}$. Tile and iron pipe on left bank 5 meters west of west right of way fence of Chicago, Burlington and Northern Railroad; 80 meters above a railroad bridge; 300 meters above section post 25–24 and milepost 213–218. Blazed trees: 9-inch lynn tree 64° (mag.)—4.5 meters; 30-inch hard maple 115° (mag.) —9.4 meters.

Elevation cap on pipe, 631.13. Bolt in tile, 627.85.

$\frac{190}{3}$. Tile and iron pipe on Island No. 189, on high ridge 80 meters from left bank of Guttenberg Channel, and about 25 meters above a patch of trees and willows along river bank. Blazed trees: 18-inch cottonwood 180° (mag.)—8.2 meters; 30-inch elm 250° (mag.)—9.2 meters.

Elevation cap on pipe, 619.15. Bolt in tile, 615.21.

$\frac{190}{4}$. Tile and iron pipe on right bank on right of way of Chicago, Milwaukee and St. Paul Railway, 1 meter from fence and 5 meters west of small ravine, 10 meters above bridge No. 238.

Elevation cap on pipe, 646.04. Bolt in tile, 642.14.

U. S. P. B. M. 249. Is about 2¼ miles below Guttenberg, Iowa, on line of Chicago, Milwaukee and St. Paul Railway, 1¼ feet east of west right of way fence and 18 feet from center of track. It is one-half mile below where track comes to the bluff and 150 feet above bridge No. 258, at the place where wagon road turns up into coulée and 24 feet east of center of road, being copper bolt in tile set 3 feet underground. Elevation, 623.69.

U. S. P. B. M. 250. Is top of cap on iron pipe over P. B. M. 249. Elevation, 627.68.

T. B. M. 252. Is about 2¼ miles below Guttenberg, Iowa, about 63 feet above U. S. P. B. Ms. 249–250, 213 feet above bridge No. 258, at lower end of cut, 17 feet east of center of track, on an imbedded bowlder marked "U. □ S.," being highest point in square. Elevation, 629.83.

T. B. M. 250. Is in Guttenberg, Iowa, on Chicago, Milwaukee and St. Paul Railway, 2,254 feet below depot, on upper abutment of bridge No. 274, on river side of track, on fourth course of stone from top, marked "U. □ S.," being highest point in square. Elevation, 623.15.

High-water marks at Guttenberg, Iowa, on east door frame of middle stone warehouse on river bank.

High water 1880, elevation 626.80; high water 1886, elevation 627.10.

Base of rail opposite Chicago, Milwaukee and St. Paul Railway depot at Gu berg, Iowa. Elevation, 627.45.

U. S. P. B. M. 248. Is in Guttenberg, Iowa, on west side of Front street, 72.7 above northwest corner of Front and Goethe streets, in the Clayton County building, 8¼ feet upstream from south side of entrance way and 3.7 feet abov bottom step, marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$, being center of copper bolt leaded horizontally. vation, 645.05.

U. S. P. B. M. 247. Is in Guttenberg, Iowa, at northeast corner of Herder First streets, on front of Joseph Huene's general store, in doorstep, 5.8 feet southwest corner of building, 4½ inches from angle of casing, and 3½ inches from face of stone, being top of copper bolt leaded vertically and marked $\overset{\text{U}}{\text{P. I}}$ Elevation, 638.44.

STONE LINE 191 (AT UPPER END OF GUTTENBERG, IOWA).

$\frac{191}{2}$. Tile and iron pipe on right of way of Chicago, Burlington and Nort Railroad, on side of bluff one-half meter from fence, 5 meters above a rai bridge, 2 meters above bend in fence where fence runs down to bridge, 110 m below milepost 221-210.

Elevation cap on pipe, 644.51. Bolt in tile, 640.55.

$\frac{191}{3}$. Tile and iron pipe on island in front of Swift Slough, 20 meters from bank of Guttenberg Channel, and about 400 meters from head of island. B trees: 36-inch elm 170° (mag.)—4.3 meters; 12-inch elm 30° (mag.)—3.6 me 12-inch ash 233° (mag.)—7.9 meters.

Elevation cap on pipe, 619.82. Bolt in tile, 615.87.

$\frac{191}{4}$. Tile and iron pipe at Guttenberg, Iowa, on property of John Hirschbu corner of Second street and Washington avenue, at his north line, 10 meters e east line of Second street.

Elevation cap on pipe, 632.33. Bolt in tile, 628.38.

T. B. M. 247. Is on right bank about 2½ miles above Guttenberg, Iowa, on Chi Milwaukee and St. Paul Railway, at lower end of bridge No. 284, on west si track, at end of first pile bent from lower end of bridge, on an oak pile proje about 2 feet above ground, being top of 6-inch wire spike, marked "□." E ticn, 623.29.

U. S. P. B. M. 245. Is on right bank, about 2¼ miles above Guttenberg, Iow Chicago, Milwaukee and St. Paul Railway, midway between bridges Nos. 284 286, and 2,000 feet below milepost 80-81, at light cut, 28.5 feet east from cent track and 2 feet west from right of way fence, 30 feet west from blazed 14- hickory tree, being copper bolt in tile set 3 feet under ground. Elevation, 624.

U. S. P. B. M. 246. Is top of cap on iron pipe over P. B. M. 245. Elevation, 62

T. B. M. 245. Is on right bank, opposite head of McMillan Island, on line of Chi Milwaukee and St. Paul Railway, about 1 mile below Eckard Station, 1,722 above mile post 79-82, and 722 feet above first road crossing below Eckard, 27 west from the center of track, on an embedded rock marked "U. □ S.," being hi point in square. Elevation, 629.87.

Base of rail opposite Chicago, Burlington and Northern Railroad depot at haven, Wis. Elevation, 631.38.

STONE LINE 192 (ABOUT ONE-HALF MILE ABOVE GLENHAVEN, WIS.).

$\frac{192}{2}$. Tile and iron pipe on right of way of Chicago, Burlington and Northern road, about one-fourth meter from fence, about 600 meters above Glenhaven, about 60 meters above point of curve of second curve above water tank at haven, immediately back of a 15-foot railroad cut, 100 meters above mouth of sl running along foot of bluffs.

Elevation cap on pipe, 658.63. Bolt in tile, 656.36.

$\frac{192}{3}$. Tile and iron pipe on right bank about 400 meters above head of McM Island, and 15 meters back from river bank; bank in front of bench mark is sloping, but about 100 meters below it is very steep. Blazed trees: 24-inch elm (mag.)—5.4 meters; 18-inch elm 5° (mag.)—5.4 meters; 18-inch birch 100° (ma 7.7 meters; 18-inch birch 177° (mag.)—6.6 meters.

Elevation cap on pipe, 620.375. Bolt in tile, 616.435.

$\frac{192}{4}$. Tile and iron pipe on left bank of slough in timber, 8 meters east of sl and 732.6 meters back from $\frac{192}{3}$. Blazed trees: 24-inch ash 162° (mag.)—19 me 24-inch birch (on bank of slough) 85° (mag.)—6 meters; 18-inch cottonwood (mag.)—17 meters.

Elevation cap on pipe, 617.94. Bolt in tile, 613.99.

U. S. P. B. M. 243. Is on right bank, one-fourth of a mile below Eckard Siding, where Chicago, Milwaukee and St. Paul Railway comes to bluff, 215 feet above milepost 78-83, opposite upper end of curve, 96½ feet west from center of track, 4½ feet from corner of fence, between fence and highway which runs parallel with the railroad. It is also 82 feet above a cluster of butternut trees, being copper bolt in tile set 3 feet underground. Elevation, 626.87.

U. S. P. B. M. 244. Is top of cap on iron pipe over P. B. M. 243. Elevation, 630.87.

Base of rail opposite Chicago, Milwaukee and St. Paul Railway depot at Eckard, Iowa. Elevation, 629.79.

T. B. M. 57, L. B. Is nail in top of north abutment of Chicago, Burlington and Northern Railroad bridge No. 135, over Sandy Creek, about 1 foot from west end and on south side of timber, about 2 feet below track. Elevation, 630.33.

T. B. M. 58, L. B. Is nail in top of north abutment of Chicago, Burlington and Northern Railroad bridge No. 136, 2 feet from west end and at south side of timber, about 2 feet below track. Elevation, 637.79.

U. S. P. B. M. 242. Is opposite the lower part of Island No. 182, nearly 3 miles below Clayton, Iowa, on line of Chicago, Milwaukee and St. Paul Railway, about 240 feet below milepost 76 and 45 feet above the highest point of heavy rock-cut waste, about the middle of long side-hill rock cut, at prominent point of bluff, in the steeply inclined face of rock, 4½ feet above grade, marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$, being center mark in copper bolt leaded horizontally. Elevation, 637.54.

T. B. M. 241. Is in same ledge as P. B. M. 242, about 4 feet farther down river and about 2 feet above grade, marked "U. □ S." on face of ledge, being highest point in square. Elevation, 635.17.

STONE LINE 193 (AT HEAD OF ISLAND NO. 182, 1 MILE BELOW BAGLEY, WIS.).

$\frac{193}{1}$. Tile and iron pipe on right of way of Chicago, Burlington and Northern Railroad, one-half meter from west fence, 120 meters below a sign, "Station One Mile," which is 1 mile below Bagley, Wis.; 220 meters below a railroad bridge, on top of sand ridge directly behind a 15-foot railroad cut.

Elevation cap on pipe, 654.70. Bolt in tile, 650.74.

$\frac{193}{2}$. Tile and iron pipe on Island No. 181, about 20 meters back from bank of river; about 400 meters above foot of island; line between $\frac{193}{2}$ and $\frac{193}{3}$ is just above head of Island No. 182. Blazed trees: 36-inch elm 75° (mag.)—4.8 meters; 10-inch maple 10° (mag.)—2.7 meters; 18-inch leaning birch 315° (mag.)—5.5 meters.

Elevation cap on pipe, 620.68. Bolt in tile, 616.73.

$\frac{193}{3}$. Copper bolt in rock on right of way of Chicago, Milwaukee and St. Paul Railway about 500 meters above milepost 76–85; opposite upper end of small curve, which is the second one above a perpendicular rock cut, and curves toward bluffs; 37 meters above a Government light, and 3 meters from center of track toward bluffs; rock is 0.6 meters higher than track, and is marked "U. S." in large letters on side facing track. Elevation, 637.775.

T. B. M. 60, L. B. Is nail in top of north abutment of Chicago, Burlington and Northern Railroad bridge No. 137, 1 foot from west end and at south side of timber; about 2 feet below track. Elevation, 630.70.

Base of rail opposite Chicago, Burlington and Northern Railroad depot at Bagley, Wis. Elevation, 633.04.

T. B. M. 239. Is on right bank, about 1 mile below Clayton, Iowa, 866 feet below milepost 74–87, 230 feet above wooden sand hopper, on the most northerly of two large bowlders, 19 feet west of center of track, being highest point of square cut on top face, 1 foot from edge, marked "U. □ S." Elevation, 638.92.

U. S. P. B. M. 241. Is at Clayton, Iowa, on south side of Main street, about 656 feet back from river bank, on southwest corner of Maine and Douglas streets, on brick building occupied by Frank Lier & Co., on east end of doorstep, marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$, being top of copper bolt leaded vertically. Elevation, 657.18.

Old U. S. B. M., also called Old P. B. M. 27. Is at Chicago, Milwaukee and St. Paul Railway depot in Clayton, Iowa, on top stone of foundation pier, at northeast corner of platform, behind center of circle, marked "⊙." Elevation, 633.01.

Base of rail opposite Chicago, Milwaukee and St. Paul Railway depot at Clayton, Iowa. Elevation, 630.34.

High-water marks at Clayton, Iowa. On large stone mill at west side of railway, in upper part of town.

High water 1870, elevation 629.62; high water 1880, elevation 630.57.

Old U. S. B. M. "b." Is in upper part of Clayton, Iowa, on large stone mill at west side of Chicago, Milwaukee and St. Paul Railway track, on river front of building, at lower end of lower window sill, being top of ringbolt, 1 inch above surface. Elevation, 629.41.

STONE LINE 194 (ABOUT ONE-FOURTH MILE ABOVE CLAYTON, IOWA).

$\frac{194}{1}$. Tile and iron pipe on right of way of Chicago, Burlington and Nort Railroad, 1½ meters from fence; on slope of bluffs; 8½ rail lengths below mile 201–230; 210 meters above signboard, "Station One Mile" (Bagley).

Elevation cap on pipe, 647.48. Bolt in tile, 643.51.

$\frac{194}{2}$. Tile and iron pipe on Island No. 181; 20 meters back from river bank; a 600 meters above small slough which empties into river opposite Clayton; abou meters below upper end of high timber. Bank in front of bench mark is steep, becomes sloping 100 meters below. Blazed trees: 24-inch white oak 104° (ma 14.2 meters; 24-inch white oak 200° (mag.)—4.3 meters; 24-inch white oak (mag.)—14.2 meters.

Elevation cap on pipe, 624.07. Bolt in tile, 620.12.

$\frac{194}{3}$. Tile and iron pipe on right of way of Chicago, Milwaukee and St. Paul way, 1½ meters from fence; on slope of bluff, 5 meters above railroad bridge No. about one-fourth mile above depot at Clayton, and 10 meters above a Govern light.

Elevation cap on pipe, 655.08. Bolt in tile, 651.14.

T. B. M. 63, L. B. Is nail in top of south abutment of Chicago, Burlington Northern Railroad bridge No. 140, about 1 foot from west end, at north side of ber, and about 3 feet below track level. Elevation, 630.63.

Base of rail opposite Chicago, Burlington and Northern Railroad depot at W sing, Wis. Elevation, 635.18.

STONE LINE 195 (AT WYALUSING, WIS.).

$\frac{195}{1}$. Tile and iron pipe directly in front of a small perpendicular rock cli meters above railroad station at Wyalusing, Wis., 36 meters east of Chicago, lington and Northern Railroad track and 1 meter from rock cliff on side of Blazed tree: 18-inch walnut 78° (mag.)—9 meters.

Elevation cap on pipe, 655.69. Bolt in tile, 651.74.

$\frac{195}{2}$. Tile and iron pipe on Island No. 176, 25 meters back from bank of about 100 meters above head of Wyalusing Slough, which is opposite Wyal Wis. Bank in front of bench mark is sloping sand. Blazed trees: 24-inch 329° (mag.)—7.3 meters; 36-inch white oak 7° (mag.)—8 meters; 24-inch oak 219° (mag.)—4.8 meters.

Elevation cap on pipe, 623.56. Bolt in tile, 619.61.

$\frac{195}{3}$. Tile and iron pipe on side of bluff, 1 meter east of perpendicular rock about 25 meters west of center of Chicago, Milwaukee and St. Paul Railway t about 40 meters above a log house, and on path leading from log house to sp 300 meters above railroad bridge No. 364 over Sny McGill Creek.

Elevation cap on pipe, 659.91. Bolt in tile, 655.96.

U. S. P. B. M. 239. Is on right bank, behind islands Nos. 176 and 178, on line o cago, Milwaukee and St. Paul Railway, 1,214 feet below lower switch block o McGill station, and 50 feet below milepost 70–91, just east of west right of way 30 feet from center of track, being copper bolt in tile set 3 feet under ground. vation, 631.41.

U. S. P. B. M. 240. Is top of cap on iron pipe over P. B. M. 239. Elevation, 63

T. B. M. 65, L. B. Is nail in top of south abutment of Chicago, Burlingto Northern Railroad bridge No. 147, about 18 inches from west end and at north s timber about 3 feet below track. Elevation, 633.75.

T. B. M. 232. Is at the head of Island No. 176, 482 feet above milepost 68 La Crosse), on the south abutment of bridge No. 378 K of the Chicago, Milw and St. Paul Railway, at its east end, on the third course of stone from top, ab feet west from east end of stone and 3 inches back from its north face, m "U. □ S.," being highest point in square. Elevation, 631.70.

T. B. M. 231. Is about one-half mile below the mouth of Wisconsin River, o south abutment of bridge No. 382 K on the river end on the second course of from the top, 1 foot from the northeast corner of stone marked "U. □ S.," the highest point in square. Elevation, 634.44.

U. S. P. B. M. 238. Is about 3½ miles below south McGregor, one-half mile belo mouth of Wisconsin River, and 1,968 feet below milepost 67 of the Chicago waukee and St. Paul Railway, 45 feet west from the center of track, directly opp the lower end of bridge No. 382 K, in which T. B. M 231 is located, in the st inclined face of hard ledge of rock, marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$, being the center of a c bolt leaded horizontally. Elevation, 642.75.

STONE LINE 196 (ABOUT ONE-HALF MILE ABOVE MOUTH OF WISCONSIN RIVER).

$\frac{196}{1}$. Tile and iron pipe one-fourth meter west of east right of way fence of Chicago, Burlington and Northern Railroad and 1 mile above bridge over Wisconsin River, 46 meters above upper end of approach to bridge (trestle), 3 meters above a fence running out to cattle guard, 125 meters below milepost 194–237.

Elevation cap on pipe, 648.42. Bolt in tile, 644.45.

$\frac{196}{2}$. Tile and iron pipe on left bank opposite Pictured Rocks, about one-half mile above mouth of Wisconsin River, and about 125 meters back from river; 10 meters back from and about 200 meters below head of small slough. Blazed trees: 10-inch birch 201° (mag.)—4.4 meters; 36-inch elm 257° (mag.)—12.4 meters; 18-inch willow 3° (mag.)—9.8 meters.

Elevation cap on pipe, 621.63. Bolt in tile, 617.68.

$\frac{196}{3}$ = P. B. M. 236–237. Tile and iron pipe about 1¼ miles below south McGregor, Iowa, on right of way of Chicago, Milwaukee and St. Paul Railway, 11 meters east of center of track, and 84 meters above milepost 66, directly opposite Pictured Rocks.

Elevation cap on pipe, 638.66. Bolt in tile, 634.66.

T. B. M. 230. Is about 1¼ miles below south McGregor, and 55 meters above milepost 66, on the bluff side of the Chicago, Milwaukee and St. Paul Railway, 15 feet from the center, on a large prominent bowlder, marked "U. □ S.," being the highest point in square. Elevation, 639.05.

Base of rail where Chicago, Milwaukee and St. Paul Railway crosses Chicago, Burlington and Northern Railroad, about one-fourth mile above B. M. $\frac{196}{1}$, and about 2¼ miles below Prairie du Chien, Wis. Elevation, 647.76.

T. B. M. 67, L. B. Is nail in top of east bent of Chicago, Milwaukee and St. Paul Railway bridge No. 374 B, about 1 foot from south end and at west side of timber, about 2 feet below track. This bridge is about 1 mile west of the Chicago, Burlington and Northern Railroad crossing and about 1¼ miles east of Prairie du Chien, Wis. Elevation, 635.23.

⊙ Praire du Chien. Elevation top of cap, 665.26. Bolt in tile, 661.31.

Base of rail opposite Chicago, Milwaukee and St. Paul Railway depot at McGregor, Iowa. Elevation, 634.06.

U. S. P. B. M. 235. Is in south McGregor, Iowa, southwest from the little park in center of the town, in the west end of the brick building owned by Mrs. J. Reynolds, and now occupied by the Huntington grain firm, 23 inches south from the northwest corner, and 4 feet and 10 inches above the ground, being center mark of copper bolt leaded horizontally, and marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$. Elevation, 639.70.

T. B. M. 228. Is in south McGregor, Iowa, at the northwest corner of Main street and the railroad, at the sidewalk entrance to Gregor McGregor's residence, on the river end of bottom step, on a level with the sidewalk, marked "U. □ S.," being highest point in square. Elevation, 635.73.

U. S. P. B. M. 234. Is in south McGregor, Iowa, on the north side of Main street, just above the Masonic Block, in brick building occupied by the Elbling cigar manufactory, in stone doorsill 2 feet from the southwest corner of building, and 4.5 inches back from the front line, being top of copper bolt leaded vertically, and marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$. Elevation, 638.55.

U. S. P. B. M. 233. Is in North McGregor, on the north side of North street, in O. A. Bratsberg's brick store, in the water table 1 foot east from the entrance, marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$, being top of copper bolt leaded vertically. Elevation, 638.18.

T. B. M. 227. Is in North McGregor, Iowa, 131 feet below the depot, 8 feet east from the southeast corner of the small wagon road and foot bridge, and 6 feet below the floor on the river end of south abutment, being the highest point in square, marked "U. □ S." Elevation, 627.62.

Base of rail opposite depot at North McGregor, Iowa. Elevation, 634.63.

U. S. Gauge is at North McGregor, at the west end of pontoon bridge, on upper side, spiked to timbering, east side of west pier, being a staff gauge. Since this gauge was connected with precise levels the zero has been raised by direction of the division engineer at Rock Island, Ill., the change of elevation being 0.60 foot, and was made October 7, 1893. Present elevation of zero, 612.20.

STONE LINE 197 (AT PRAIRIE DU CHIEN, WIS.).

$\frac{197}{1}$. Tile and iron pipe in Prairie du Chien; in old stock yards one-fourth meter west of east line of property of Chicago, Milwaukee and St. Paul Railway, about

150 meters back from river, and directly back of large elevator 2 blocks south
Dousman House; 48 meters south of south line of Bridge street.

Elevation cap on pipe, 630.58. Bolt in tile, 626.62.

$\frac{197}{3}$. Copper bolt in solid rock, and iron pipe; one half meter east of perpendicu
rock cliff and at an elevation about 9 meters higher than railroad tracks; 15 met
above sign $\boxed{\begin{array}{c}\text{R. R. CROSSING}\\ \text{STOP}\\ \text{400 FEET.}\end{array}}$ which is at upper end of North McGregor, where bluffs co
out to tracks. Fifteen-inch hackberry tree —1¼ meters.

Elevation cap on pipe, 673.64. Bolt in tile, 670.91.

Base of rail opposite waiting room of Chicago, Milwaukee and St. Paul Railw
Depot at Prairie du Chien, Wis. Elevation, 632.39.

High-water mark at Prairie du Chien, Wis. Is a black line across a cement bl
2 feet square, in north end of Diamond Jo warehouse. Made by Diamond Jo ag
about the time. High water, June 10, 1880. Elevation, 633.76.

Diamond Jo Gauge at Prairie du Chien, Wis. Is fastened to piling at north end
Diamond Jo warehouse. At time of high water in June, 1880 (preceding desc
tion), this gauge read 22.1 feet. Since then it has been disturbed by other h
waters and the zero raised. Elevation of zero, 612.12.

U. S. P. B. M. 232. Is in Prairie du Chien, 2,100 feet below the east end of
Chicago, Milwaukee and St. Paul Railway Bridge across the Mississippi Rive
the river front of the Dousman House, on the upper end of the stone window sil
the first window below the upper entrance, being top of a copper bolt leaded ve
cally, and marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$. Elevation, 637.96.

Old U. S. B. M. "a." Is in Prairie du Chien, on the Dousman House, on the do
stream end of the downstream doorsill, being the highest point in circle, cut in sto
Elevation, 637.96.

U. S. Gauge at Prairie du Chien, Wis. Is nailed to piling at east side of draw
Chicago, Milwaukee and St. Paul Railway Bridge. Elevation of zero, 612.11.

T. B. M. 226. Is in Prairie du Chien, on the east end of the Chicago, Milwau
and St. Paul Railway Bridge across the Mississippi River, on the south end of
over the piles at end, being top of drift bolt over pile, marked with a square "
Elevation, 632.91.

T. B. M. 225. Is in northeastern part of Prairie du Chien, on east side of str
and about 75 feet south of St. Gabriel's Catholic church, at the street entrance
Father Kramer's residence, on southeast corner of large stone step, marked "U. □
being highest point in square. Elevation, 646.11.

U. S. P. B. M. 231. Is in Prairie du Chien, on the west end of St. Gabriel's chu
19 inches from north side and 4 feet above ground, marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$, being cente
copper bolt leaded horizontally. Elevation, 650.36.

Ⓐ South Base (Prairie du Chien, Wis.). Elevation cap on pipe, 625.35. Bolt
tile, 621.48.

Ⓐ North Base (near Prairie du Chien, Wis.). Elevation cap on pipe, 622.08. B
in tile, 618.11.

T. B. M. 17, R. B. Is top of rock 3 feet below track on Bridge No. 408 K, on Chica
Milwaukee and St. Paul Railway. On extreme upstream corner of the river end
downstream abutment of bridge and 10 feet toward river from center of tra
Opposite foot of first small island on right bank, 1¼ miles above North McGreg
Iowa. Elevation, 633.59.

STONE LINE 198 (CROSSES RIVER ABOUT 3 MILES ABOVE PRAIRIE DU CHIEN, W AT HEAD OF ISLAND NO. 167).

$\frac{198}{1}$. Tile and iron pipe planted on property belonging to Franklin Walter, 1 me
east of east fence of wagon road which runs north from Prairie du Chien; 39 met
north of north fence of road running east 600 meters west of foot of bluff. Wag
road running east runs into first ravine north of Ⓐ Dousman. A brick house sta
south of B. M. about 50 meters.

Elevation cap on pipe, 638.29. Bolt in tile, 634.33.

$\frac{198}{2}$. Tile and iron pipe planted on Island No. 166, 20 meters back from shore,
high ground, about 600 meters above head of Island No. 169. To 24-inch elm 3
19′—4.5 meters; to 12-inch elm 161° 49′—66.3 meters.

Elevation top of cap, 626.95. Bolt in tile, 622.97.

$\frac{198}{3}$. Tile and iron pipe planted on right bank on south side of bluff about one-h
mile above Yellow River. About 300 meters above Yellow River Railroad stati
Opposite a point 5 meters above head block of switch, 15 meters west of center of r
road track. To 18-inch pin oak 88° 23′—4.5 meters; to 12-inch pin oak 183° 53′—
meters.

Elevation: Top of cap, 666.55; bolt in tile, 662.58.

T. B. M. 18, R. B. Is top of rock pier in center of Chicago, Milwaukee and St. Paul Railway bridge No. 422 K, about 1¼ miles above Yellow River and 100 meters below Hanging Rock. On upstream end and river side of pier on extreme corner; 2.7 feet below track and 8 feet from center. Elevation, 634.41.

T. B. M. 68, L. B. Is nail in top of south abutment of Chicago, Burlington and Northern Railroad bridge No. 153, about 18 inches from west end and 10 inches from side of timber. About 2 feet below track. This bridge is about 20 meters above milepost 243. Elevation, 634.46.

T. B. M. 19, R. B. Is □ cut on top of north abutment of Chicago, Milwaukee and St. Paul Railway bridge No. 428 K, on south side and river end of abutment; 11 feet east of center of track and 3.1 feet below it. This bridge is the third above milepost 58-103 and above first house below Johnsonport, which is 1¼ miles upstream. Elevation, 634.03.

T. B. M. 69, L. B. Is nail in top of south abutment of Chicago, Burlington and Northern Railroad bridge No. 156, about 2 feet from west end and at north side of timber. This bridge is about 75 meters above milepost 244. Elevation, 635.20.

U. S. P. B. M. 229. Is on left bank, about 3 miles below Charme Station, on line of Chicago, Burlington and Northern Railroad, at G. L. Miller's place, now occupied by M. Sage, 257 feet below section post 30-29, 72 feet above a bridge, 127 feet from southwest corner of house, and 95 feet from northeast corner of barn, on right of way, 18 inches east of west fence, being copper bolt in tile 3 feet underground. Elevation, 637.37.

U. S. P. B. M. 230. Is top of cap on iron pipe over P. B. M. 229. Elevation, 641.37.

STONE LINE 199 (CROSSES RIVER ABOVE JOHNSONPORT, IOWA, AT MOUTH OF PAINT CREEK).

$\frac{199}{1}$. Tile and iron pipe planted on side of Wisconsin bluffs, about 600 meters below Picatee Creek. Six meters east of east right of way fence of Chicago, Burlington and Northern Railroad. About opposite a point 10 meters below a telegraph pole marked $\begin{array}{c}1\\8\\4\\ \hline 5\end{array}$, 100 meters below upper end of railroad curve. First curve below Picatee Creek. To 18-inch oak 222° 51′—8.8 meters; to 10-inch oak 331° 21′—3.5 meters.

Elevation top of cap, 670.08. Bolt in tile, 666.12.

$\frac{199}{2}$. Tile and iron pipe planted on Island No. 166. On high ground at west edge of garden and 30 meters below small house at north end of cultivated field, about 20 meters back from shore, and 15 meters south of a dead 4-foot cottonwood, which branches into four prongs about 12 feet above ground. Opposite mouth of Paint Creek and about 800 meters below a Government light. To 48-inch cottonwood (with 4 prongs) 174° 37′—14.7 meters; to 30-inch birch 63° 52′—13.5 meters.

Elevation cap of pipe, 630.97. Bolt in tile, 627.01.

$\frac{199}{3}$. Tile and iron pipe planted 2 meters west of west right of way fence of Chicago, Milwaukee and St. Paul Railway, 150 meters above mouth of Paint Creek, 143 meters above bridge No. 438 K, and 200 meters above last house in upper end of Johnsonport. To 10-inch double butternut 143° 38′—19.0 meters; to 12-inch double butternut 112° 38′—9.5 meters.

Elevation cap on pipe, 648.12. Bolt in tile, 644.16.

T. B. M. 218. Is on left bank about 1¼ miles below Charme Station, on line of Chicago, Burlington and Northern Railroad, 518 feet below milepost 185, at north edge of farm crossing, on an embedded bowlder, 25 feet east from center of track, marked "U. □ S.," being highest point in square. Elevation, 638.85.

STONE LINE 200 (CROSSES RIVER AT FOOT OF ISLAND NO. 164, 6 MILES BELOW LYNXVILLE, WIS.).

$\frac{200}{1}$. Tile and iron pipe planted 1¼ meters east of right of way fence of Chicago, Burlington and Northern Railroad. About 50 meters above foot of Island No. 164, 160 meters above head block of switch, and 185 meters above bridge No. 167. To 12-inch oak 327° 18′—8.5 meters; to 8-inch oak 236° 18′—6.0 meters.

Elevation cap on pipe, 663.73. Bolt in tile, 659.77.

$\frac{200}{2}$. Tile and iron pipe planted on Island No. 163, on high ground in bunch of cottonwoods, 30 meters back from east shore, 100 meters above a running slough opposite foot of Island No. 164, and 25 meters north of small dry slough. To 24-inch cottonwood 253° 52′—4.7 meters; to 20-inch double cottonwood 356° 17′—2.8 meters; to 18-inch cottonwood 123° 22′—6.6 meters.

Elevation cap on pipe, 625.89. Bolt in tile, 621.93.

$\frac{200}{3}$. Tile and iron pipe planted at foot of bluffs, about one-half mile above Ⓐ Painted Rocks, in corner of fences, 1 meter west of west right of way fence of Chicago, Milwaukee and St. Paul Railway, 15 meters north of road crossing, 30 meters below bridge No. 456, and about 1¼ miles above Waucon Junction, Iowa. To 12-i walnut 126° 05′—12.5 meters: to 10-inch oak 69° 05′—13.1 meters.

Elevation cap on pipe, 644.18. Bolt in tile, 640.21.

P. B. M. 226. Is about 1 mile above Charme, Wis., on line of Chicago, Burling and Northern Railroad, 1,959 feet above milepost 183, and 180 feet below bridge 171; about 1,700 feet below the large flat piece of ledge standing on edge betw railroad and river, 16 feet high, at the east railroad fence, being copper bolt in set 3 feet underground. Elevation, 637.68.

U. S. P. B. M. 227. Is top of cap on iron pipe over P. B. M. 226. Elevat 641.69.

T. B. M. 215. Is about 1 mile above Charme, Wis., on the line of the Chica Burlington and Northern Railroad, at the lower end of wooded point of lanc shore, and 1,689 feet below the large flat piece of ledge standing on edge betw railroad and river, 16 feet high; it is also 180 feet below bridge No. 171, and 1 feet above milepost 183, 30 feet from center of track, on an embedded bowl marked "U. □ S.," being the highest point in square. Elevation, 636.08.

T. B. M. 20, R. B. Is □ cut on northeast corner of downstream stone abutmen Chicago, Milwaukee and St. Paul Railway bridge No. 462 K, at lower end of bot land where Harpers Slough strikes bluffs, about 1½ miles below Harpers Ferry, Io T. B. M. is 2.5 feet below track, on first course of stone, and 9 feet east of cen Elevation, 637.17.

T. B. M. 21, R. B. At Harpers Ferry, Iowa. Is nail in river-side root of cot wood tree, one-half meter west of fence parallel with river. This tree is nearest water's edge of any in vicinity and is about 300 meters north of barn with st foundation. One block north of Chestnut street, which runs east and west thro Harpers Ferry. Elevation, 625.22.

T. B. M. 213. Is 1¼ miles below Viola, about in center of the first cut be bridge No. 175, 639 feet distant, and 1,529 feet above milepost 181, 3 feet above gr on natural ledge of rock, marked "U. □ S." on face, being the highest point square. Elevation, 642 30.

STONE LINE 201 (CROSSES RIVER AT HEAD OF ISLAND NO. 162).

$\frac{201}{2}$. Tile and iron pipe planted at foot of bluffs, 2 meters west of east right of fence of Chicago, Burlington, and Northern Railroad, 40 meters below head of Isl No. 162, and 12 meters north of gate in road leading up large ravine.

Elevation cap on pipe, 651.19. Bolt in tile, 647.24.

$\frac{201}{3}$. Tile and iron pipe opposite head of Island No. 162, on an irregular sha island just below Island No. 161, in small clump of heavy timber, 15 meters f shore. To 30-inch cottonwood 292° 28′—11 meters; to 15-inch elm 46° 28′—5 met to 20-inch maple 119° 58′—3.5 meters.

Elevation cap on pipe, 626.54. Bolt in tile, 622.57.

$\frac{201}{4}$. Tile and iron pipe planted on main bank, about 600 meters from foot of blu one-half meter east of fence along wagon road, 500 meters below a two story fr house standing opposite ◬ Oil Spring, 150 meters below land line between J Martell on north and Peter Joice on south, 150 meters below upper end of ro cottonwood trees standing along bank of slough, and about 1¼ miles above Har Ferry, Iowa.

Elevation cap on pipe, 648.99. Bolt in tile, 645.06.

T. B. M. 212. Is one-half mile below Viola, 702 feet above milepost 180, 9.3 east of the center of the Chicago, Burlington and Northern Railroad track natural ledge of rock marked "U. □ S.," being the highest point in square. Ele tion, 641.79.

T. B. M. 211. Is at Viola, about 3¼ miles below Lynxville, 1,345 feet below bri No. 176, near the upper end of the first cut, 525 feet below Mr. Caya's house, j above a large cubical rock lying at water's edge, and 12 feet east from cente track of the Chicago, Burlington and Northern Railroad, on a rock marked "U. □ being highest point in square. Elevation, 639.45.

U. S. P. B. M. 224. Is at Viola, about 3⅛ miles below Lynxville, 909 feet be bridge No. 176, being 436 feet above T. B. M. 211, in the southwest corner of Caya's dooryard, 95 feet from the southwest corner of his red frame house, 50 southeast from track, and 1 foot north from line of fence, being a copper bolt in set 3 feet underground. Elevation, 636.93.

U. S. P. B. M. 225. Is at Viola, being top of cap on iron pipe set over P. B. M. Elevation, 640.93.

T. B. M. 22, R. B. About 3 miles above Harpers Ferry, Iowa. Is □ cut on high part of river side of flat rock 7 feet square lying at water's edge, 35 meters eas Chicago, Milwaukee and St. Paul Railway track along foot of bluff and 85 met above milepost 48–113. Elevation, 625.85.

STONE LINE 202 (CROSSES RIVER ABOUT 1¼ MILES BELOW LYNXVILLE, WIS.).

${}^{202}_{\;1}$. Tile and iron pipe planted one-half meter west of east right of way fence of Chicago, Burlington and Northern Railroad, 2 meters north of angle in fence, 54 meters below culvert No. 265, and 350 meters below "One Mile" sign below Lynxville. Bench mark is on north side of small ravine.

Elevation cap on pipe, 650.10. Bolt in tile, 646.14.

${}^{202}_{\;2}$. Tile and iron pipe planted on Island No. 158, about 150 meters below head of island, on high ground in bunch of elms, 50 meters back from shore. To 24-inch elm, 73°—6.2 meters; to 24-inch elm, 109° 15′—7.3 meters; to 30-inch elm, 183°—3.6 meters.

Elevation cap on pipe, 625.50. Bolt in tile, 621.54.

${}^{202}_{\;3}$. Tile and iron pipe planted opposite Lynxville, at side of old wagon road, one-half meter west of west right of way fence of Chicago, Milwaukee and St. Paul Railway, and nearly opposite upper end of railroad curve. B. M. stands on side of a bald, grassy, round-topped bluff, 200 meters below where Harpers Slough turns away from bluffs towards Lynxville. To 8-inch black oak 45°—7 meters; to 20-inch pin oak 150°—26 meters.

Elevation cap on pipe, 660.78. Bolt in tile, 656.85.

T. B. M. 209. Is about three-fourths mile below Lynxville, Wis., 623 feet below bridge No. 179, in middle of light cut, 66 feet above milepost 177, on west side of Chicago, Burlington and Northern Railroad track, 12 feet from center, on large embedded bowlder, marked "U. □ S.," being highest point in square. Elevation, 639.62.

U. S. P. B. M. 223. Is in Lynxville, Wis., on the north side of the principal street running back from the river, on the south front of Mr. King's brick store, in the east end of the doorsill, being top of copper bolt leaded vertically, and marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$. Elevation, 645.45.

Old U. S. B. M. Is on Bright's warehouse at Lynxville, Wis., on northeast corner of building, 984 feet below Chicago, Burlington and Northern Railroad depot, on top of foundation, marked "B. ⊙ M.," being highest point in circle. Elevation, 644.85

High-water marks at Lynxville, Wis., are lines cut in side of wood jamb at west side of door in north end of T. C. Bright's warehouse on river bank and adjoining Chicago, Burlington and Northern Railroad, and about 300 meters below depot.

High-water mark 1870, elevation 635.66; high-water mark 1880, elevation 636.58.

Base of rail opposite Chicago, Burlington and Northern Railroad depot at Lynxville, Wis. Elevation, 641.89.

T. B. M. 207. Is at north end of Lynxville, Wis., at Chicago, Burlington and Northern Railroad depot, on foundation stone of water tank, on south one of the two west piers, marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$, being top of copper bolt leaded vertically. Elevation, 642.05.

U. S. P. B. M. 221. Is on left bank, about 1¼ miles above Lynxville, Wis., at Coopers Coulée, 56 feet above milepost 175, 35 feet west from center of Chicago, Burlington and Northern Railroad track, outside of right of way, about 1½ feet from fence and 25 feet east from a forked oak tree, being copper bolt in tile set 3 feet under ground. Elevation, 636.65.

U. S. P. B. M. 222. Is top of cap on iron pipe over P. B. M. 221. Elevation, 640.65.

T. B. M. 206. Is about 10 feet down track from P. B. M's 221–222, 12 feet west of center of track on embedded rock, marked "U. □ S.", being highest point in square. Elevation, 639.68.

STONE LINE 203 (CROSSES RIVER AT HEAD OF CROOKED SLOUGH).

${}^{203}_{\;1}$. Tile and iron pipe planted one-half meter east of east right of way fence of Chicago, Burlington and Northern Railroad, about one-half mile below ◬ Dagnon, about 2¼ miles above Lynxville, 180 meters below lower end of long railroad curve, and about 250 meters above lower end of island.

Elevation cap on pipe, 654.48. Bolt in tile, 650.53.

${}^{203}_{\;2}$. Tile and iron pipe planted on Island No. 151, 50 meters back from shore, about opposite center of small island, and a little below a point opposite a Government light. Two large elms stand close to bench mark, one of which appears to be the tallest tree in the vicinity. Head of small island is in line with ${}^{203}_{\;1}$ and ${}^{203}_{\;3}$. To 40-inch elm 50° 59′—6.9 meters; to 36-inch elm 169° 29′—9.7 meters; 36-inch maple 212° 59′—25.2 meters.

Elevation cap on pipe, 626.58. Bolt in tile, 622.62.

${}^{203}_{\;3}$. Tile and iron pipe planted at foot of bluffs, along wagon road, 1 meter west

of west right of way fence of Chicago, Milwaukee and St. Paul Railway, oppo
head of Crooked Slough, 175 meters below a sign $\boxed{\begin{array}{c}\text{1500 FT.}\\\text{TO STA.}\end{array}}$ (Heytmans), 15 me
above whistling post, and 25 meters above lower end of small curve. To 10-i
black oak 52° 41′—19 meters; to 10-inch black oak 103° 56′—16.5 meters; to 10-i
black oak 156° 56′—26.2 meters.

Elevation cap on pipe, 658.17. Bolt in tile, 654.21.

T. B. M. 23, R. B. About 6½ miles below Lansing, Iowa, and 1 mile above Heytm
Landing, is □ cut on downstream side and river end of upstream stone abutm
of Chicago, Milwaukee and St. Paul Railway bridge No. 504 K. T. B. M. is 2.7
below top of rail and 12 feet toward river from center of track. About 300 me
below signboard "Station 1 mile," and 70 feet above whistling post. Elevat
640.78.

U. S. P. B. M. 219. Is 4 miles below Ferryville, Wis., at the place where the Wi
shiek Slough comes in to railroad, opposite south end of bridge, 46 feet east f
center of track, 15 feet west from wagon road and 15 feet south from center of bri
or "cattle pass," in corner of fence, being copper bolt in tile set 3 feet undergrou
Elevation, 631.48.

U. S. P. B. M. 220. Is top of cap on iron pipe over P. B. M. 219. Elevation, 635

T. B. M. 204. Is 4 miles below Ferryville, Wis., at the place where the Winnes
slough comes in to railroad, 1,247 feet below milepost 172, on the north side of bri
east of track, at corner of fence, on an embedded bowlder, marked "U. □ S.," b
the highest point in square. Elevation, 636.80.

T. B. M. 202. Is 1¼ miles below Ferryville, Wis., at the lower end of a light cut,
feet below milepost 170, 12 feet west of the Chicago, Burlington and Northern Rail
track, on a hard gray sandstone, embedded and marked "U. □ S.," being the hig
point in square. Elevation, 642.36.

Base of rail opposite Chicago, Burlington and Northern Railroad depot at Fe
ville, Wis. Elevation, 640.51.

U. S. P. B. M. 217. Is in Ferryville, Wis., 164 feet above the Chicago, Burlington
Northern Railroad depot, and 29½ feet east of center of track, 39 feet from the sou
east corner of J. S. Oleson's house and store, all at the upper side of road cross
being a copper bolt in tile set 3 feet underground. Elevation, 635.86.

U. S. P. B. M. 218. Is top of cap on iron pipe set over P. B. M. 217. Elevation, 63

STONE LINE 204 (CROSSES RIVER 6 MILES BELOW LANSING, IOWA).

$2\underset{1}{0}4$. Tile and iron pipe planted in southeast corner of lot belonging to W
Robertson, in Ferryville, Wis. On side of bluff about 150 meters above railr
station.

Elevation cap on pipe, 685.37. Bolt in tile, 681.39.

$2\underset{2}{0}4$. Tile and iron pipe planted on Carol Island, 250 meters below head of Fe
Slough and 25 meters back from shore. Bench mark is opposite foot of first sn
island below head of Ferry Slough. The line between $2\underset{2}{0}4$ and $2\underset{3}{0}4$ passes betw
first and second islands below head of Ferry Slough. Bench mark is 100 me
above a log cabin, in bunch of elms. To 30-inch elm 67° 30′—11.0 meters; to 18-i
elm 39° 15′—11.7 meters; to 48-inch elm 157° 00′—5.6 meters.

Elevation cap on pipe, 629.53. Bolt in tile, 625.56.

$2\underset{3}{0}4$. Tile and iron pipe planted on right bank directly under Capoli Bluff, c
half meter outside of right of way fence of Chicago, Milwaukee and St. Paul R
way (bluff side), and about 25 meters above upper end of sharp curve around f
of Capoli Bluff. To 12-inch elm 323° 51′—5.4 meters; to 20-inch oak 108° 06′—
meters.

Elevation cap on pipe, 665.31. Bolt in tile, 661.37.

T. B. M. 200. Is 4,593 feet above Ferryville, on line of the Chicago, Burlington
Northern Railroad, near the upper end of the first cut above Ferryville, 1,256
above milepost 168 and 213 feet above bridge, 10 feet east of center of track o
large flat rock embedded, being the highest point in square, marked "U. □
Elevation, 639.86.

T. B. M. 24, R. B. About 5 miles below Lansing, Iowa. Is □ cut on large rock
upstream side and river end of downstream abutment of Chicago, Milwaukee
St. Paul Railway bridge No. 510 K. Is 1.65 feet below track and 10 feet tow
river from center. Elevation, 642.89.

U. S. P. B. M. 215. Is about 2½ miles above Ferryville, Wis., 18 feet below T
M. 198, 394 feet below the lower end of long trestle over Rush Creek, and 94 me
below milepost 166, opposite a blazed elm standing on the east side of wagon ro
also 328 feet below a blazed elm between railroad and wagon road near south en
trestle, being a copper bolt in tile about 3 feet underground. Elevation, 639.25.

U. S. P. B. M. 216. Is top of cap on iron pipe set over P. B. M. 215. Elevati
643.25.

T. B. M. 198. Is on left bank, about 2¼ miles above Ferryville, Wis., on Chicago, Burlington and Northern Railroad, 290 feet below milepost 166, and 377 feet below south end of long trestle over Rush Creek, on the east side of track, at right of way fence, 17 feet from center of track, on embedded rock, marked "U. □ S.", being highest point in square. Elevation, 640.53.

STONE LINE 205 (CROSSES RIVER ABOUT 2¼ MILES BELOW LANSING, IOWA, AND ABOUT ONE-HALF MILE ABOVE ISLAND NO. 147).

$\frac{204}{1} = \frac{205}{1}$. Tile and iron pipe planted one-half meter outside of right of way of Chicago, Burlington and Northern Railroad (bluff side), about 3 miles above Ferryville, Wis., three-fourths mile above Rush Creek, 260 meters below culvert No. 288, and 360 meters below milepost 165–266. To 18-inch oak 130° (mag.)—4.3 meters.

Elevation cap on pipe, 664.12. Bolt in tile, 660.18.

$\frac{205}{2}$. Tile and iron pipe planted on large island, about 400 meters above head of Island No. 148, in bunch of willows, 50 meters back from shore, and 150 meters above head of a bay. To 10-inch willow 336° 02′—2 meters; to 12-inch willow 207° 52′—6.5 meters; to 10-inch willow (double) 107° 16′—10 meters.

Elevation cap on pipe, 626.39. Bolt in tile, 622.44.

$\frac{205}{3}$. Tile and iron pipe planted in meadow at foot of bluffs on property of Julius Nelson, one-half meter toward bluffs from fence along wagon road, about 2 miles below depot at Lansing, Iowa, 155 meters below milepost 123–38, and 120 meters above culvert No. 518. To 12-inch butternut 354° 23′—12.2 meters; to 10-inch butternut 62° 08′—23 meters; to 12-inch butternut 29° 53′—18.1 meters.

Elevation cap on pipe, 664.68. Bolt in tile, 660.72.

Base of rail opposite Chicago, Milwaukee and St. Paul Railway depot at Lansing, Iowa. Elevation, 639.63.

T. B. M. 25, R. B. At Lansing, Iowa. Is □ cut on track side of △-shaped stone on top of upstream abutment, at river end, of Chicago, Milwaukee and St. Paul Railway Bridge No. 526 K, 150 meters above depot. Is 1.5 feet below track and 23.6 feet toward river from center of track. Elevation, 638.94.

High-water mark at Lansing, Iowa, on southeast corner of G. W. Herndt's warehouse. High water, June, 1880, elevation, 640.92.

Gauge at Lansing, Iowa, is painted board nailed on coal dock at foot of Main street, and is owned by Hoyne & Co. Elevation of zero, 619.31.

STONE LINE 206 (CROSSES RIVER 1 MILE ABOVE RAILROAD STATION AT LANSING, IOWA).

$\frac{206}{1}$. Tile and iron pipe planted on high ground in bunch of elms 40 meters back from shore at Government light on Island No. 146, opposite upper end of Lansing, Iowa. To 24-inch elm, 186° 54′—3.2 meters; to 24-inch elm, 307° 24′—18 meters; 24-inch elm 338° 24′—9.1 meters.

Elevation cap on pipe, 630.52. Bolt in tile, 626.56.

$\frac{206}{2}$. Tile and iron pipe planted at foot of bluffs, 34 meters back from railroad, opposite 1-mile post above Lansing depot, about 75 meters above an old mill that stands on bank of slough and is last building in upper end of Lansing. To 12-inch butternut 335° 48′—12 meters; to 12-inch butternut 69° 48′—7.7 meters; to 8-inch butternut 138° 18′—7.2 meters.

Elevation cap on pipe, 655.72. Bolt in tile, 651.78.

T. B. M. 196. Is on left bank, about 2 miles below De Soto, Wis., 1,315 feet above milepost 164 on line of Chicago, Burlington and Northern Railroad, 361 feet above bridge and 90 feet above very large rock at east fence in small cut at foot of east slope, 12 feet from center of track, on an embedded bowlder marked "U. □ S.", being highest point in square. Elevation, 642.68.

U. S. P. B. M. 213. Is 1¼ miles below De Soto, Wis., on line of Chicago, Burlington and Northern Railroad, at upper end of stretch where Winneshiek Slough comes back to railroad, 394 feet below milepost 163, at west fence, 26 feet from center of track, at lower end of rock cut, being copper bolt in tile set 3 feet underground. Elevation, 638.69.

U. S. P. B. M. 214. Is top of cap on iron pipe over P. B. M. 213. Elevation, 642.65.

T. B. M. 195. Is about 32 feet above P. B. M. 213, 360 feet below milepost 163, 15 feet west of center of track, being highest point in square, on rock, marked "U. □ S." Elevation, 643.56.

T. B. M. 26, R. B. About 1¼ miles above Lansing, Iowa. Is □ cut on upstream side and river end of downstream abutment of Chicago, Milwaukee and St. Paul Railway bridge No. 530 K. T. B. M. is 0.8 foot below track and 7 feet east of center. Elevation, 644.30.

STONE LINE 207 (CROSSES RIVER AT LOWER END OF DE SOTO, WIS., AT RAIL WATER TANK).

$\frac{207}{2}$ = P. B. M. 212. In foundation of Chicago, Burlington and Northern Rail water tank at De Soto, in top stone of the south one of the two west piers, l top of copper bolt leaded vertically. Marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$.
Elevation, 643.52.

$\frac{207}{3}$. Tile and iron pipe planted on Island No. 140, opposite foot of Island No. 30 meters back from shore, 100 meters below upper end of timber, 30 meters b an old shed inside a lot, and 1 meter from east fence. To 40-inch cottonwood 04′—6.6 meters; to 36-inch elm 101° 34′—4.6 meters.

Elevation cap on pipe, 631.62. Bolt in tile, 627.65.

$\frac{207}{4}$. Tile and iron pipe planted at foot of bluffs, about 3 miles above Lan Iowa, 1 meter east of west right of way fence of Chicago, Milwaukee and St. Railway, 425 meters above bridge No. 540 K, 475 meters above a house, about half mile above Ⓐ Cowles, opposite end of railroad curve, and about one-half below a schoolhouse. To 18-inch oak 65° 54′—8.2 meters.

Elevation cap on pipe, 651.10. Bolt in tile, 647.14.

Base of rail opposite Chicago, Burlington and Northern Railroad depot at De Wis. Elevation, 643.24.

U. S. P. B. M. 211. Is in the upper end of De Soto, on the north side of Diamond Jo warehouse, 9 inches from the west side, and 5.3 feet above the gro being the center mark in copper bolt leaded horizontally. Marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$. Eleva 633.55.

High-water mark at De Soto, Wis., made by the water at time of flood, or wood columns on second floor of warehouse of De Soto Lumber Company (no made any exact mark). High water 1880. Approximate elevation, 638.79.

T. B. M. 193. Is in the upper end of De Soto, Wis., at the warehouse form owned by C. Lytel & Co., now owned by the De Soto Lumber Company, on the s end of the south top stone of pier supporting runway over the Chicago, Burlin and Northern Railroad track, 7.2 feet east from the center of track, being hig point in square, marked "U. □ S." Elevation, 649.16.

T. B. M. 192. Is about a mile above De Soto, Wis., 1,138 feet above milepost in cut 12 feet east from the center of the Chicago, Burlington and Northern Rail on an embedded bowlder, being the highest point in square, marked "U. □ S." vation, 645.05.

Ⓐ Lower base (near De Soto, Wis.). Top of cap, 631.36. Bolt in tile, 627.42.

Ⓐ Upper base (near De Soto, Wis.). Top of cap, 632.50. Bolt in tile, 628.55.

T. B. M. 27, R. B. About 3½ miles above Lansing, Iowa. Is □ cut on downst side and river end of upstream stone abutment of Chicago, Milwaukee and St. Railway bridge No. 546 K, 3 feet below track and 8 feet toward river from ce Elevation, 642.68.

Base of rail at Kains Siding, Iowa, Chicago, Milwaukee and St. Paul Rail Elevation, 641.47.

STONE LINE 208 (CROSSES RIVER ABOUT THE CENTER OF BATTLE ISLAND, 3 M ABOVE DE SOTO, WIS.).

$\frac{208}{1}$ = P. B. M.'s 209–210. Is 2¼ miles above De Soto, 164 feet east from bridge 307 over Battle Creek, and 36 feet east from wagon road, at the north side of n wire fence of lane leading from Richard Valliant's house, being copper bolt in set 3 feet underground.

Elevation cap on pipe, 644.33. Bolt in tile, 640.32.

$\frac{208}{2}$. Tile and iron pipe planted on Battle Island (No. 137), on high sand ri about one-half mile above foot of island, about 75 meters from edge of sand ba meters from main bank, and 100 meters below lower end of small willows on To 12-inch maple 165° 40′—2 meters; to 15-inch elm 199° 10′—4.5 meters; to 15- elm 327° 55′—2.7 meters.

Elevation cap on pipe, 633.02. Bolt in tile, 629.07.

$\frac{208}{3}$. Tile and iron pipe planted on Island No. 139, about opposite center of Ba Island, 100 meters back from bank of river, and 25 meters below south end of across slough. To 18-inch ash 23° 31′—6.7 meters; to 15-inch ash 114° 01′—7.7 met

Elevation cap on pipe, 630.83. Bolt in tile, 626.89.

$\frac{208}{4}$. Tile and iron pipe planted on Island No. 139, in timber on west bank of s dry slough, in bend of large slough, 50 meters east and 50 meters south from ban slough. Azimuth 105° 58′; distance 694.4 meters from B. M. $\frac{208}{3}$. To 18-inch m 73° 30′ (mag.)—5.8 meters; to 18-inch birch 272° (mag.)—6 meters; to 24-inch 222° (mag.)—12 meters.

Elevation cap on pipe, 632.43. Bolt in tile, 628.49.

T. B. M. 190. Is 2¼ miles above De Soto, in the same vicinity as P. B. M's 209–210, on the line of the Chicago, Burlington, and Northern Railroad on bridge over Battle Creek, in the seventh bent from the south end, on the west end of cap, being top of spike in square. Elevation, 640.69.

T. B. M. 28, R. B. About 5 miles below New Albin, Iowa, and 1 mile above Kains Siding, Iowa. Is □ cut on upstream side and river end of downstream abutment of Chicago, Milwaukee and St. Paul Railway bridge No. 560 K, about 125 meters above milepost 29–132. Is 3 feet below track and 10 feet toward river from center. Elevation, 643.14.

T. B. M. 188. Is 1 mile below Victory depot, on line of the Chicago, Burlington and Northern Railroad, 2,100 feet above milepost 158 and 197 feet above bridge, 30 feet east of center of track on an embedded bowlder, marked "U. □ S.," being the highest point in square. Elevation, 645.46.

U. S. P. B. M. 208. Is in Victory, Wis., on the southeast corner of block 17, and at the northeast corner of Terhune and Rice streets, on the south abutment, west side of wagon bridge, on the corner top stone, 3 inches from end of wall, being top of copper bolt leaded vertically, marked $\underset{\text{P. B. M.}}{\overset{\text{U. S.}}{\odot}}$. Elevation, 647.43.

Base of rail opposite Chicago, Burlington and Northern Railroad Depot at Victory, Wis. Elevation, 644.47.

STONE LINE 209 (CROSSES RIVER ABOUT 300 METERS BELOW TIPPETS LANDING, WISCONSIN).

$\frac{209}{2}$ = P. B. M.'s 206–207. Is at Tippets Landing, 1,296 feet below the old warehouse, 33¼ feet east of the Chicago, Burlington and Northern Railroad. It is also 1 mile above Victory, in the bed of the old wagon road under the bluffs used before the railroad was built, being top of copper bolt leaded in tile.

Elevation cap on pipe, 653.74. Bolt in tile, 649.73.

$\frac{209}{3}$. Tile and iron pipe planted on ridge, 100 meters above its lower end, and 100 meters above lower end of timber. On Island No. 135, 50 meters back from shore and 200 meters below a point opposite warehouse at Tippets Landing. To 18-inch birch 38° 36'—5 meters; to 12-inch oak 212° 55'—3 meters; to 18-inch oak 280° 25'—4 meters.

Elevation cap on pipe, 633.01. Bolt in tile, 629.05.

$\frac{209}{4}$. Tile and iron pipe planted in low ground, in small bunch of willows, about 75 meters east from east bank of Lost Slough. From $\frac{209}{3}$ to $\frac{209}{4}$, 105° 05'—677 meters. To 24-inch lone elm on high ground 175° (mag.)—14 meters.

Elevation cap on pipe, 629.41. Bolt in tile, 625.45.

T. B. M. 186. Is at Tippets Landing, Wisconsin, about 150 feet above P. B. M.'s 206–207, 1,640 feet below Tippet's house and 1,128 feet below warehouse on river bank, 12 feet west of center of track, on an embedded rock marked "U. □ S.", being highest point in square. Elevation, 648.07.

Base of rail opposite Chicago, Milwaukee and St. Paul Railway depot at New Albin, Iowa. Elevation, 655.49.

T. B. M. 29, R. B. At New Albin, Iowa. Is top of city corner stone on west side of Chicago, Milwaukee and St. Paul Railway track, 2 blocks north of depot and just north of grain elevator. Elevation, 657.08.

T. B. M. 30, R. B. At New Albin, Iowa. Is top of pipe monument on State line between Iowa and Minnesota. Elevation, 655.70.

T. B. M. 31, R. B. At New Albin, Iowa. Is top of city corner stone which is on Iowa-Minnesota State line and 35 meters west of pipe monument, and 8 meters east of east right of way fence of Chicago, Milwaukee and St. Paul Railway. Elevation, 655.02.

T. B. M. 32, R. B. About 1¼ miles north of Iowa-Minnesota State line. Is □ cut on northwest corner of west end of south abutment of Chicago, Milwaukee and St. Paul Railway bridge No. 590 K, 2.8 feet below track and 7.7 feet west from center of track. Elevation, 641.90.

U. S. P. B. M. 204. Is 2¾ miles below Genoa, Wis., on line of Chicago, Burlington and Northern Railroad, about 360 feet below milepost 153, 147 feet above a bridge and 93½ feet below John T. Elger's house, 34¼ feet east from center of track, being copper bolt in tile set 3 feet underground. Elevation, 641.48.

U. S. P. B. M. 205. Is top of cap on iron pipe over P. B. M. 204. Elevation, 645.48.

STONE LINE 210 (CROSSES RIVER 150 METERS ABOVE HEAD OF ISLAND NO. 128).

$\frac{210}{1}$. Tile and iron pipe planted 807.7 meters back of $\frac{210}{2}$, 1 meter west of east right of way fence of Chicago, Burlington and Northern Railroad, 80 meters above a 20-foot trestle, No. 222, at upper side of large ravine. In front of a bare rocky cliff, and

50 meters below upper edge of cultivated lot. About one-fourth mile below post 152.

Elevation cap on pipe, 655.19. Bolt in tile, 651.21.

${}^{2}{}^{1}_{2}{}^{0}$. Tile and iron pipe planted in scattering timber on left bank, 8 meters river bank, 100 meters above a point opposite head of Island No. 128, and ba lower end of sand bar. To 10-inch birch 298° 46′—4.5 meters; to 6-inch el 16′—8 meters; to 14-inch birch 187° 46′—3 meters.

Elevation cap on pipe, 635.45. Bolt in tile, 631.49.

${}^{2}{}^{1}_{3}{}^{0}$. Tile and iron pipe planted 150 meters above head of Island No. 128, 25 m from top of bank, and about midway between first and second wing dams above of Island No. 128. To 30-inch elm 110° 25′—6 meters; to 15-inch elm 205 meters; to 12-inch ash 358°—10 meters.

Elevation cap on pipe, 635.01. Bolt in tile, 631.04.

${}^{2}{}^{1}_{4}{}^{0}$. Tile and iron pipe planted in timber, on ridge back of small slough. B. M. ${}^{2}{}^{1}_{3}{}^{0}$ to ${}^{2}{}^{1}_{4}{}^{0}$, 84° 02′—760.6 meters. To 15-inch elm (double) 350° (mag. meters; to 24-inch elm 252° (mag.)—12 meters; to 18-inch elm 192¼° (mag. meters.

Elevation cap on pipe, 634.26. Bolt in tile, 630.30.

Old U. S. B. M. "i," also called old P. B. M. 21. Is in Genoa, Wis., on last building in town, going south, on river front of building, second floor, on ups corner of stone doorsill, being highest point in square. Elevation, 617.06.

High water mark at Genoa, Wis. Is cut in west front at south end of stone at lower end of town, a little below depot and close to Chicago, Burlingto Northern Railroad. Same house on which old U. S. B. M. "i" is located. Eleva 642.89.

Base of rail opposite Chicago, Burlington and Northern Railroad depot at G Wis. Elevation, 645.88.

STONE LINE 211 (CROSSES RIVER AT GENOA, WIS.).

${}^{2}{}^{1}_{2}{}^{1}$. Tile and iron pipe planted in Genoa, in church lot, one-half meter e north and south fence, and 50 meters south of church.

Elevation cap on pipe, 703.50. Bolt in tile, 699.53.

${}^{2}{}^{1}_{3}{}^{1}$. Tile and iron pipe planted opposite Genoa, 15 meters from shore, on meter south of an east and west wire fence, and 100 meters below the lower log of two, 100 meters below mouth of small slough. To 24-inch double cotton 329° 24′—38.9 meters.

Elevation cap on pipe, 636.34. Bolt in tile, 632.36.

${}^{2}{}^{1}_{4}{}^{1}$. Tile and iron pipe planted between two lakes, and about opposite cen first lake back of ${}^{2}{}^{1}_{3}{}^{1}$. At upper end of small patch of willows and 100 meters of east bank of large lake. From ${}^{2}{}^{1}_{3}{}^{1}$ to ${}^{2}{}^{1}_{4}{}^{1}$, 106° 55′ 30″—741.7 meters.

Elevation cap on pipe, 631.38. Bolt in tile, 627.41.

U. S. P. B. M. 203. Is at Genoa, Wis., on west side of Main street, in front of A Zabolio's store, on stone doorstep of upstream door, near southeast corner of being top of copper bolt leaded vertically, marked $\overset{\text{U. S.}}{\underset{\text{P. B. M.}}{\odot}}$. Elevation, 663.84.

T. B. M. 178. Is one-half mile above Genoa, Wis., 2,326 feet below milepost 1 front of the large stone house of John Franzini, on rough bowlder, on the eas of the highway which runs along east of railroad, being the highest point in sq marked "U. □ S." Elevation, 649.16.

T. B. M. 33, R. B. About 1 mile below Reno Junction, Minn., and is □ c upstream side and river end of downstream stone abutment of Chicago, Milw and St. Paul Railway bridge No. 614 K, 2.3 feet below track and 8.3 feet east o ter. Elevation, 642.92.

Base of rail opposite depot at Reno Junction, Minn., on Chicago, Milwauke St. Paul Railway. Elevation, 645.19.

T. B. M. 34, R. B. About 1 mile above Reno Junction, Minn., on line of Chi Milwaukee and St. Paul Railway, at junction of Raft Channel and Minnesota Sl Is □ cut on downstream side and river end of upstream stone abutment of b No. 626 K, 2 feet below track and 8 feet toward river from center. Directly from head of island. Elevation, 643.52.

T. M. B. 177. Is 1½ miles above Genoa depot, on line of Chicago, Burlington Northern Railroad, 2,516 feet below milepost 148, and 656 feet below P. B. M. 2 feet east of center of track on large rock, marked "U. □ S.", being highest poi quare Elevation, 647.27.

U. S. P. B. M. 201. Is 1⅝ miles above Genoa, on right of way of Chicago, Bur ton and Northern Railroad, 351 feet below bridge No. 226 and 1,837 feet below post 148, at east fence, in front of Frank Riley's property, being copper bolt in set 3 feet underground. Elevation, 645.41.

U.S.P.B.M. 202. Is top of cap on iron pipe set over P. B. M. 201. Elevation, 649.43.

T.B.M. 175. Is at Britts Landing, 75 feet above milepost 147, on the east side of track, on a rock, being the highest point in square, marked "U. □ S." Elevation, 640.79.

U.S.P.B.M. 199. Is at Warners Landing, 280½ feet up the track from O. Warner's house, 60 feet above bridge No. 235, and 29.2 feet east of the center of the track, on the Chicago, Burlington and Northern Railroad right of way, at the east fence, being copper bolt in tile set 3 feet underground. Elevation, 643.86.

U.S.P.B.M. 200. Is top of cap on iron pipe set over P.B.M. 199. Elevation, 647.86.

STONE LINE 212 (CROSSES RIVER ABOUT 4 MILES ABOVE GENOA, AT FAIRY ROCK).

$^{2}{}_{1}{}^{2}$. Tile and iron pipe planted 968.78 meters, azimuth 207° 29′ from $^{2}{}_{2}{}^{2}$. B. M. stands at edge of first large timber reached after leaving river bank. To 15-inch ash 179° (mag.)—5.5 meters; to 12-inch willow 293° (mag.)—9.5 meters; to 18-inch willow (double) 114° (mag.)—7.1 meters.

Elevation cap on pipe, 634.38. Bolt in tile, 630.42.

$^{2}{}_{2}{}^{2}$. Tile and iron pipe planted 10 meters from river, opposite foot of small slim island directly opposite Fairy Rock, and also opposite a 1½-story frame house. To 24-inch cottonwood 160° 21′—4.9 meters; to 28-inch willow 221° 56′—3.4 meters; to 18-inch willow 317° 21′—8 meters.

Elevation cap on pipe, 638.16. Bolt in tile, 634.26.

$^{2}{}_{3}{}^{2}$. Tile and iron pipe planted at foot of bluffs, one-half meter east of west fence of wagon road, 25 meters west of center of track of Chicago, Milwaukee and St. Paul Railway, 90 meters above bridge No. 630 K, about 25 meters below a 1½-story frame house, about 150 meters below Fairy Rock.

Elevation cap on pipe, 656.86. Bolt in tile, 652.93.

TOPOGRAPHY AND HYDROGRAPHY FROM NEAR BROWNSVILLE, MINN. (751 MILES ABOVE CAIRO, ILL.), NORTHWARD.

The general survey of the river was resumed May 20, 1897, at the upper limit of the work of 1896, near Brownsville, Minn. The party organization and plant used in this work is practically the same as that enumerated in connection with the work of last season. The members of the office force belonging to the field party and a number of laborers left St. Louis on May 18 by rail for La Crosse, Wis., where they were met by the remainder of the party with the steamer *Patrol*, survey boat *Illinois*, and fuel barge, having the field equipment on board.

The river being somewhat too high for satisfactory work in the bottoms, the survey will be confined to the bluffs and lands above overflow until such time as the stage is favorable for hydrography and survey of the bars and low lands.

DISCHARGE MEASUREMENTS.

The discharge work has been carried on by a party in charge of E. L. Harman, and quartered on the steamer *Search*.

The measurements were made with the Haskell current meter, operated from the steamer, and also with double floats.

Low-water measurements were made of the main river at Columbus, Ky.; Helena, Ark.; Arkansas City, Ark., and Carrollton, La. Measurements of the low-water discharge of the following tributaries were also made: St. Francis River at Park Place, about 15 miles above the mouth; White River at a point about 16 miles above the mouth; Arkansas River at Hopedale, about 18 miles from the mouth; Yazoo River at Mound View Landing, about 28 miles from its mouth; Black River at Davids Landing, about 2 miles above its junction with the Red River; Red River at Jefferson Landing, about 22 miles above its junction with the Mississippi; Atchafalaya River at Simmsport, 4 miles below Old River.

High-water discharge measurements were made of the Mississippi River during the spring of 1897 at the following points: Columbus, Ky.; Helena, Ark., Arkansas City, Ark.; Warrenton, Miss.; Red River Landing, La.; and Carrollton, La. The discharge of the Atchafalaya River at flood stage was also measured.

The results of these discharge measurements have been deduced from the original notes under the direction of Kivas Tully, and will be found in the tabulations following:

Results of discharge observations.

MISSISSIPPI RIVER, COLUMBUS, KY. (21 MILES BELOW CAIRO).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
				Area.		Depth.											
	Belmont.	Local.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.	Width.								
1896.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*			
Nov. 2	6.9	6.95	0.0	72,060	173,926	28.1	55.9	42	2,568	....	a 2.022	a 145,740	....	....	9	48	V—Strong.
3	7.1	7.02	+ .2	72,521	174,212	28.2	56	41.2	2,572	+ 286	2.348	170,316	....	....	9	41	Do.
4	7.4	7.35	+ .3	72,478	173,318	28.1	55.7	42	2,575	— 894	2.224	161,171	....	....	10	53	III—Very light.
4	7.4	7.35	....	72,478	....	28.1	....	42	2,575	....	a 2.218	a 160,718	....	....	5	53	
5	7.7	7.67	+ .3	74,945	174,960	29.1	56.2	42.6	2,577	+1,642	2.146	160,823	....	....	10	52	IV—Strong.
5	7.7	7.67	....	74,945	....	29.1	....	42.6	2,577	....	a 2.029	a 152,076	....	....	9	52	IV—Light.
6	8.2	8.17	+ .5	75,990	174,711	29.5	56.1	43.9	2,580	— 249	2.174	165,228	....	....	10	52	V—Brisk.
7	8.6	8.50	+ .4	77,522	175,388	30	56.3	44.1	2,581	+ 677	1.975	153,109	....	....	10	52	IX—Brisk.
9	9.6	9.60	+1	80,520	175,535	31	56.4	45.5	2,599	+ 147	2.346	188,855	....	....	10	52	V—Brisk.
9	9.6	9.70	....	79,986	174,741	30.7	56.1	46.1	2,604	— 794	a 2.371	a 189,629	....	....	10	53	IV—Strong.
10	9.8	9.80	+ .2	79,447	173,942	30.5	55.9	46.1	2,608	— 799	....	....	....	....	.....	.....	V—Very strong.
1897.																	
Mar. 3	39.2	39.32	+ .9	167,856	177,694	54.1	57.1	78.2	3,096	+3,752	7.101	1,188,409	....	....	14	51	X to XII—Brisk to light.
4	39.9	39.91	+ .7	172,807	180,819	55.6	58.1	80.4	3,100	+3,125	7.257	1,250,446	....	....	14	51	III—Very light.
5	40.6	40.57	+ .7	170,763	177,230	55	56.9	80.3	3,105	—3,589	8.012	1,368,188	....	....	14	39	Drft. very bad. V—Brisk to light.
6	41.2	b 41.15	+ .6	172,685	177,349	55.6	57	80.4	3,106	+ 119	7.347	1,268,752	....	....	14	51	XI—Variable.
6	41.2	41.15	....	172,685	....	55.6	....	80.4	3,106	....	a 7.756	a 1,339,319	....	....	14	51	XII—Brisk.
8	42.3	42.36	+1.1	177,554	178,457	57	57.3	81	3,113	+1,108	7.753	1,376,624	....	....	14	51	V—Brisk.
9	42.5	42.65	+ .2	178,389	178,389	57.3	57.3	82.4	3,113	— 68	7.806	1,392,483	....	....	14	51	V—Light.
9	42.5	42.65	....	178,389	....	57.3	....	82.4	3,113	....	a 8.197	a 1,462,347	....	....	14	31	V—Strong.

a Float observations; all others meter.

b River bank full; over bank on some places on Belmont side.

NOTES.—The discharge section was located at the same place as in former years, the right bank end being about 2,840 feet below the Belmont elevator.

The float observations were taken between ranges about 484 feet apart; double floats were used, the lower one being at mid-depth. The meter observations were made with the Haskell current meter, held at six-tenths depth for five minutes. For values of meter constants see page 3662.

The first column of gauge readings are the means of 8 a. m. and 4 p. m. from the regular Mississippi River Commission Belmont records and change in twenty-four hours is derived from this column. Elevation of Belmont gauge zero is 286.85 feet above Cairo datum plane. "Local" gauge column contains means of readings taken by discharge party during observations. Datum line is taken at 42.65 feet on Belmont gauge as observed March 9, 1897.

MISSISSIPPI RIVER, HELENA, ARK. (306 MILES BELOW CAIRO).

HELENA.

1896.																	
Nov. 18	7.1	7.10	+0.2	57,948	206,890	29.6	42	51.4	1,955	....	a3,407	a197,400	....	....	11	30	V—Mild.
19	7.9	7.75	+ .8	59,548	207,201	30.5	42.1	53.8	1,955	+ 311	3,428	203,812	....	....	11	39	I—Light.
20	8.9	8.55	+1.	60,785	206,876	30.7	42	53.8	1,980	— 325	3,597	218,670	....	....	11	39	XII—Very light.
20	8.9	8.83	....	61,380	206,912	31	42	54.1	1,980	+ 36	a3,724	a228,605	....	....	11	39	I—Light.
21	9.7	9.43	+ .8	63,037	207,375	31.8	42.1	55	1,985	+ 463	3,557	224,234	....	....	10	40	VI—Very light.
21	9.7	9.52	....	63,387	207,554	31.6	42.1	57.5	2,005	+ 179	a3,529	a223,675	....	....	11	40	VII—Light.
23	10.4	10.40	+ .7	65,018	207,418	32.4	42.1	56.5	2,010	— 186	3,796	246,798	....	....	11	40	Calm.
23	10.4	10.42	....	65,276	207,636	32.5	42.2	56.1	2,010	+ 218	3,782	246,864	....	....	11	40	IV—Light.
24	10.4	10.40	....	64,489	206,889	32.1	42	56.1	2,010	— 747	3,760	242,500	....	....	12	40	IV—Very light.
24	10.4	10.38	....	64,961	207,401	32.3	42.1	56	2,010	+ 512	a3,515	a228,329	....	....	11	40	IV—Light.
1897.																	
Mar. 12	42.8	43.09	+ .6	191,376	220,712	39	44.8	83.9	4,902	+13,811	5,987	1,145,689	....	....	19	19	I—Light.
13	43.5	b43.57	+ .7	190,309	217,309	38.7	44.1	88	4,910	— 3,403	6,063	1,153,846	....	....	19	71	I to XII—Light.
15	44.7	44.90	+1.2	200,737	221,208	40.8	44.9	88.5	4,916	+ 3,899	6,255	1,255,626	....	....	9	22	XII—Light.
16	45.4	45.55	+ .7	206,042	223,320	41.9	45.3	87.8	4,919	+ 2,112	6,219	1,281,486	....	....	19	58	II—Very light.
17	45.8	45.96	+ .4	197,683	212,946	40.2	43.2	88.9	4,921	—10,374	6,274	1,240,251	....	....	19	71	IV to XII—Light.
19	47.7	47.72	+1.9	204,848	211,449	41.6	42.9	90.1	4,926	— 1,497	6,685	1,369,392	c2,267	1,371,659	19	71	VI to VII—Light to strong.
20	48.4	48.39	+ .7	210,531	213,831	42.7	43.4	89.7	4,926	+ 2,382	6,815	1,484,741	....	....	19	71	VII—Light.
20	48.4	48.39	....	210,531	....	42.7	....	89.7	4,926	....	a6,485	a1,365,250	....	....	19	71	VI—Very light.
22	49	49.06	+ .6	219,807	219,807	44.6	44.6	93.1	4,926	+ 5,976	6,761	1,486,222	....	....	19	71	XII—Nearly calm.
22	49	49.06	....	219,807	....	44.6	....	93.1	4,926	....	a6,740	a1,481,408	....	....	20	71	Do.

a Velocities were observed with floats; all others were with meter. The float observations were taken with double floats, the lower float being at mid-depth. The distance apart of ranges was 400 feet during low water observations and 480 feet during high water observations. The meter observations were made with the Haskell meter, held at six-tenths depth, generally for five minutes. For value of meter constants see page 3662.

b Water just over bank at this gauge reading.

c Right bank.

NOTES.—The discharge section was about one-half mile below Helena; United States Coast and Geodetic Survey Ⓐ North base, on right bank, was in line of section. Approximate azimuth 277°.

The gauge used was the United States engineer gauge at Helena, whose zero is 161.98 feet above Cairo datum plane. The first column of gauge readings are the means of 8 a. m. and 4 p. m., and the changes in twenty-four hours are derived from this column. The "local" column gives means of readings taken by the discharge party during observations. The datum line is taken at 49.06 feet on the gauge as observed March 22, 1897.

Results of discharge observations—Continued.

MISSISSIPPI RIVER, ARKANSAS CITY, ARK. (488 MILES BELOW CAIRO).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard.	Local.	Rise or fall in the preceding 24 hours.	Area.		Depth.			Width.								
				Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1896.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*			
Dec. 4	11.9	11.35	+1.6	78,180	215,492	24	62.1	52.8	3,258	....	3.651	285,470	....	....	16	66	IV—Very mild.
5	14.2	13.60	+2.3	87,119	217,073	26.5	62.5	54.9	3,282	+ 1,581	3.940	343,217	....	....	9	66	IV—Calm to brisk.
5	14.2	14.25	....	88,439	216,237	26.9	62.3	55	3,283	— 836	4.054	358,500	....	....	10	66	IV—Light.
5	14.2	14.55	....	89,796	216,603	27.3	62.4	55.4	3,285	+ 366	*a* 4.020	*a* 360,957	....	....	12	66	IV—Brisk.
7	18.2	18.24	+4	103,154	217,765	30.9	62.7	60.5	3,335	+ 1,162	4.417	455,679	....	....	12	67	Calm.
7	18.2	18.75	....	105,553	218,468	31.5	62.9	60.8	3,346	+ 703	4.420	466,583	....	....	12	68	Do.
8	20	19.95	+1.8	109,874	218,768	32.8	63	61.8	3,352	+ 300	4.458	489,801	....	....	12	68	V—Light.
9	21	20.76	+1	115,066	221,240	34.3	63.7	63.5	3,358	+ 2,472	4.381	504,093	....	....	12	69	X—Light.
9	21	21.02	....	116,300	221,602	34.6	63.8	61.5	3,363	+ 362	4.431	515,318	....	....	12	68	X—Very light.
9	21	21.02	....	116,300	....	34.6	....	61.5	3,363	....	*a* 4.290	*a* 498,911	....	....	17	68	Nearly calm.
1897.																	
Mar. 25	50.8	50.68	+ .6	242,438	246,629	69.8	71.1	94.8	3,471	+25,027	6.540	1,585,594	*b* 9,997	1,595,591	17	69	IX to X—Light to brisk.
26 *c*	51.1	51.15	+ .3	234,429	236,998	67.5	68.3	95.5	3,471	— 9,631	6.769	1,586,809	*b* 10,164	1,596,973	18	69	III to VI—Light.
27	51.4	51.50	+ .3	236,954	238,308	68.3	68.8	96.8	3,471	+ 1,310	6.904	1,635,956	*b* 10,331	1,646,287	18	56	X—Variable.
29	51.9	51.89	+ .5	236,838	236,838	68.2	68.2	96.3	3,471	— 1,470	6.788	1,607,766	*d* 4,516	1,618,097	18	69	III—Variable.
30	51.4	51.60	— .5	....	....	....	....	....	....	....	....	....	*e* 5,815				
30	51.4	51.34	....	234,761	236,660	67.6	68.2	95.7	3,471	— 178	*a* 6.825	*a* 1,602,223	10,331	1,612,554	18	69	III—Strong.

a Velocities were observed with floats; all others were with meter. The float observations were taken between ranges 400 feet apart; double floats were used, the lower one being at mid-depth. The meter observations were made with the Haskell current meter, held at six-tenths depth for five minutes.

b Deduced from observed overflow of March 29 and 30.

c Boils are quite bad from Station 11 to 16. They evidently indicate traveling sand. The remarkable changes in depth from the preceding day were checked by resounding.

d Left bank.

e Right bank.

NOTES.—The discharge section was at same place as in former years—about one-half mile below Arkansas City.

The regular Mississippi River Commission gauge at Arkansas City was used; the elevation of its zero is 116.44 feet above the Cairo datum plane. The first column of readings are means of 8 a. m. and 4 p. m., and changes in twenty-four hours are derived from this column. The "local" column gives means of readings taken by the discharge party during observations. The datum line is taken at 51.89 feet on the gauge as observed March 29, 1897.

MISSISSIPPI RIVER, WARRENTON, MISS. (608 MILES BELOW CAIRO).

	Vicksburg.																
1897.																	
pr. 1........	49.35	100	+0.1	230,009	238,535	61.2	63.5	93.9	3,756	....	7.171	1,649,498	13,858	1,663,856	12	51	XII—Nearly calm.
2........	49.35	100	.0	223,081	231,607	59.4	61.7	93.5	3,756	—6,928	7.318	1,632,490	13,858	1,646,348	13	42	III—Very light.
3........	49.25	99.99	—.1	225,062	233,625	59.9	62.2	93	3,756	+2,018	7.088	1,595,295	13,858	1,609,153	19	75	III-VI—Calm to strong.
5........	49.25	99.99	.0	227,370	235,934	60.5	62.8	93.8	3,756	+2,309	6.741	1,532,806	13,858	1,546,664	19	75	XI—Very light.
6........	49.30	100	.0	a228,473	....	60.8	....	....	3,756	....	b6.494	b1,483,759	3,912 c9,946	1,497,617	19	....	Do.
7........	49.35	100.05	.0	229,576	237,914	61.1	63.3	93.6	3,756	+1,980	6.897	1,583,441	14,184	1,597,625	19	75	XII—Calm to brisk.
8........	49.60	100.20	+.2	233,397	241,172	62.1	64.2	92.8	3,756	+3,258	7.039	1,642,786	15,814	1,658,600	19	75	VI—Strong to light.
9........	49.85	100.50	+.2	238,183	244,831	63.4	65.2	94.7	3,756	+3,659	7.001	1,667,492	17,444	1,684,936	19	75	XI—Strong.
10........	50.15	100.73	+.3	240,513	246,297	64	65.6	94.6	3,756	+1,466	6.727	1,617,830	19,400	1,637,239	15	55	VI—Light.
12........	50.90	101.33	+.3	241,798	245,329	64.4	65.3	93.8	3,756	— 968	7.035	1,700,991	24,290	1,725,281	19	75	V—Strong.
13........	51.30	101.60	+.4	237,836	240,352	63.3	64	93.5	3,756	—4,977	7.232	1,720,100	26,898	1,746,998	19	74	VII—Light.
14........	51.55	101.84	+.2	c243,314	....	64.8	....	....	3,756	....	b6.871	b1,671,869	d28,513	1,700,382	19	....	VII-XI—Light to strong.
15........	51.95	102.27	+.4	248,785	248,785	66.2	66.2	93.9	3,756	+8,483	7.018	1,746,059	31,121	1,777,180	19	74	I—Light to calm.

a Interpolated from preceding and following days. b Velocities were observed with floats; all others were with meter. c Partly observed. d Observed.

NOTES.—The discharge section was at same place as in former years, which is about 1½ miles below old Warrenton Landing, and 607.8 miles on the inch-mile map.

The discharge on right bank was measured on April 6 and 14. The first measurement was not extended as far as the overflow, and was corrected by 3,912 cubic feet deduced from the second measurement. This corrected overbank discharge has been adopted for April 1 to 5, and the overbank between April 6 and 14 was interpolated from those dates; that for April 15 was derived from the observed overbank discharge of the 14th.

Vicksburg gauge zero is 66.04 feet above the Cairo datum.

The "local" gauge was high-water gauge No. 74, at old Warrenton Landing. Readings on this gauge are referred to Memphis datum, which is 18.13 feet above the Cairo datum; change in twenty-four hours is derived from Vicksburg gauge.

Results of discharge observations—Continued.

MISSISSIPPI RIVER, RED RIVER LANDING, LA. (765 MILES BELOW CAIRO).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard.	Local.	Rise or fall in the preceding 24 hours.	Area.		Depth.			Width.								
				Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1897.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*			
Apr. 21	47.70 47.75	47.74	+0.1	213,355	223,320	52.5	54.9	85.2	4,064	....	5.722	1,220,858	*a* 6,487	1,227,345	16	36	VI—Brisk.
22	47.85 47.90	47.86	+ .2	212,107	221,584	52.2	54.4	84.1	4,064	−1,736	5.793	1,228,686	*b* 6,487	1,235,173	16	60	V—Strong.
24	48 48.05	48.15	+ .2	220,372	228,671	54.2	56.2	84.4	4,064	+7,087	5.580	1,229,650	7,339	1,236,989	16	61	VI—Nearly calm.
26	48.40 48.45	48.41	+ .4	223,798	231,039	55.1	56.7	85.5	4,064	+2,368	5.636	1,261,241	9,871	1,271,112	16	60	I—Nearly calm.
28	48.62 48.71	48.65	+ .2	223,844	230,110	55.1	56.5	84.6	4,066	− 929	5.544	1,241,027	10,079	1,251,106	16	61	IV—Nearly calm to brisk.
30	48.95 49	48.98	+ .3	227,735	232,659	56	57.1	85.1	4,068	+2,549	5.518	1,256,590	10,535	1,267,125	16	61	XI—Brisk.
May 3	49.22 49.30	49.24	+ .3	232,315	236,182	57.1	58	84.4	4,068	+3,523	5.453	1,266,851	13,437	1,280,288	16	61	XII—Very light.
5	49.52 49.58	49.55	+ .3	234,438	237,044	57.6	58.2	85.6	4,072	+ 862	5.322	1,247,677	14,364	1,262,041	16	61	XII—Calm to light.
7	49.75 49.78	49.76	+ .2	236,928	238,678	58.2	58.6	84.5	4,072	+1,634	5.109	1,210,383	13,398	1,223,781	16	61	IV—Very light.
10	49.98 50	49.99	+ .2	234,554	235,369	57.6	57.8	84.8	4,072	−3,309	5.257	1,233,062	16,026	1,249,088	16	63	VI—Light.
12	50.10 50.13	50.12	+ .1	236,237	236,522	58	58.1	85.5	4,072	+1,153	5.393	1,274,128	14,727	1,288,855	16	68	Nearly calm.
14	50.18 50.20	50.19	+ .1	237,664	237,664	58.4	58.4	85.4	4,072	+1,142	5.264	1,251,048	15,096	1,266,144	16	62	XII—Variable.
14	....	50.19	....	237,664	....	58.4	....	....	4,072	....	*c* 5.365	*c* 1,275,084	15,096	1,290,180	16	....	XII—Light.

a Assumed to be as observed on the following day.

b This discharge, which was on the right bank, was through open timber with very little underbrush. There was no discharge on left bank, but the country was covered with standing water.

c Velocities were observed with double floats, the lower float being at mid-depth. All other discharges were observed with the Haskell current meter, which was run at six-tenths depth at each station for five minutes.

NOTES.—The discharge section was located just below Red River Landing, La., at the same place as in former years.

ATCHAFALAYA RIVER, SIMMSPORT, LA.

	Barbre Landing.																	
1896.																		
Dec. 21	14.52 14.28	9.28	—0.5	25,805	....	32	....	44.6	806	....	1.381	35,646	....	....	8	31	Calm.
21	....	9.26	....	25,872	....	32.1	....	44.6	806	....	1.414	36,580	....	....	8	31	Do.
21	....	9.20	....	25,799	....	32	....	44.6	805	....	1.308	33,742	....	....	8	31	VIII—Light.
21	....	9.15	....	25,863	....	32.1	....	44.6	805	....	1.339	34,632	....	....	10	31	VII—Light.
21	....	9.12	....	25,841	....	32.1	....	44.1	805	....	1.322	34,162	....	....	10	31	VII—Very light.
22	13.58 13.37	8.71	—.9	25,452	....	31.7	....	44.8	801	....	a1.412	a35,937	....	....	10	31	Calm.
22	....	8.69	....	25,185	....	31.4	....	44	801	....	a1.380	a34,757	....	....	10	31	V—Very light.
22	....	8.66	....	25,297	....	31.6	....	44	801	....	1.349	34,128	....	....	10	31	V—Light.
22	....	8.63	....	25,216	....	31.5	....	43.2	801	....	1.320	33,297	....	....	10	31	VI—Strong.
22	....	8.60	....	25,167	....	31.4	....	43.3	801	....	1.233	31,036	....	....	10	31	VI—Brisk.
1897.																		
Apr. 23	48.33 48.40	....	+.2	62,268	....	56.8	....	83	1,097	....	5.525	344,054	b10,572 c 2,816	356,942	11	44	III—Brisk.
27	49.05 49.10	....	+.2	63,481	....	57.8	....	85.3	1,099	....	5.278	335,083	12,829 2,680	350,592	12	60	III—Calm to brisk.
29	49.40 49.48	1.17	+.2	63,631	65,180	57.9	59.3	84.9	1,099	....	5.522	351,377	12,926 3,691	367,994	10	55	VIII—Strong.
May 1	49.75 49.80	1.46	+.2	64,382	65,612	58.6	59.7	86.4	1,099	+432	5.604	360,780	10,151 3,797	374,728	11	48	X—Strong.
4	50.15 50.22	1.86	+.2	64,459	65,250	58.7	59.4	88.3	1,099	—362	5.510	355,176	13,225 5,102	373,503	7	48	XII—Light.
6	50.45 50.48	2.11	+.1	65,343	65,860	59.5	59.9	88.7	1,099	+610	5.670	370,477	12,788 5,716	388,981	7	50	
8	50.62 50.65	2.33	+.1	65,280	65,554	59.4	59.6	88.9	1,099	—306	5.585	364,597	13,326 6,435	384,358	7	55	III—Very light.
11	50.83 50.88	2.53	+.1	66,030	66,085	60.1	60.1	89.6	1,099	+531	5.604	370,001	13,410 6,431	389,842	7	54	Nearly calm.
13	50.95 50.95	2.58	.0	66,251	66,251	60.3	60.3	90	1,099	+166	5.834	386,493	12,477 6,682	405,652	7	55	IX—Calm to light.

a Float observations; all others meter. *b* Right bank discharge, including that of Alligator Bayou. *c* Left bank discharge.

NOTES.—The discharge section was located about midway between sill dams Nos. 1 and 3, at about the mouth of Alligator Bayou, upper edge of Simmsport, La.; marks of former discharge section could not be found.

The float observations were taken between ranges 150 feet apart; double floats were used, the lower one being at mid-depth. The meter observations were made with the Haskell current meter, held at six-tenths depth for five minutes. For values of meter constants see page 3662.

The first column of gauge readings are the means of 8 a. m. and 4 p. m., from the regular Mississippi River Commission Barbre Landing records, and change in twenty-four hours is derived from this column. Elevation of Barbre Landing gauge zero is 24.17 feet above Cairo datum plane.

"Local" gauge column contains means of readings taken by discharge party during observations. The gauge used in December, 1896, was not connected with any datum; the one used in April and May, 1897, is the high-water gauge set by Louisiana State Engineer Richardson; the elevation of its zero is 70.92 feet above Cairo datum, which zero was high water of 1893. Datum line is taken at 2.58 on "local" gauge as observed May 13, 1897.

Result of discharge observations—Continued.

MISSISSIPPI RIVER, CARROLLTON, LA. (957 MILES BELOW CAIRO).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard.	Local.	Rise or fall in the preceding 24 hours.	Area.		Depth.			Width.								
				Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1897.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*			
Jan. 1	2.90 3.35	3.20	+1	152,696	188,372	68.5	80.2	95.1	2,229	....	*a* 2.077	*a* 317,081	....	....	10	44	IV—Strong. *b*
2	2.55 2.70	2.85	—.5	151,222	187,677	68.1	79.9	94.6	2,221	— 695	*a* 2.331	*a* 352,458	....	....	11	44	Do. *b*
2	....	....	....	151,222	....	68.1	....	....	2,221	....	*a* 2.197	*a* 332,229	....	....	10	....	Do. *b*
2	....	3.02	....	152,506	188,583	68.4	80.2	96.2	2,229	+ 906	*a* 2.152	*a* 328,238	....	....	11	40	IV—Very strong. *b*
2	....	....	....	152,506	....	68.4	....	....	2,229	....	*a* 2.005	*a* 305,834	....	....	10	....	Do. *b*
4	2.10 1.95	2.30	—.5	148,983	186,656	67.5	79.4	93.8	2,208	—1,927	2.629	391,635	....	....	11	44	XI—Strong.
4	....	2.08	....	148,054	186,096	67.4	79.2	94.1	2,196	— 560	2.515	372,340	....	....	11	44	XI—Brisk.
5	2.00 2.10	2.30	.0	148,350	186,022	67.3	79.2	94.3	2,205	— 74	2.609	387,017	....	....	11	44	X—Stiff.
5	....	1.70	....	146,554	185,547	66.8	79	92.7	2,194	— 475	*a* 2.542	*a* 372,542	....	....	11	44	IX—Strong.
6	2.05 2.15	1.80	.0	147,650	186,423	67.3	79.3	93.4	2,195	+ 876	2.286	337,563	....	....	11	44	I—Variable.
6	....	....	....	147,650	....	67.3	....	....	2,195	....	2.263	334,080	....	....	11	....	XII—Light.
May 18	18.60 18.70	18.77	—.1	184,803	184,803	78.6	78.6	110.1	2,350	—1,620	7.295	1,348,156	1,932	1,350,088	13	48	III—Strong.
19	18.60 18.70	18.69	.0	183,889	184,077	78.2	78.3	109.6	2,350	— 726	7.184	1,321,186	*c* 1,960	1,323,146	13	50	I to XI—Light.
19	....	....	....	183,889	....	78.2	....	....	2,350	....	6.721	*a* 1,235,976	*c* 1,960	1,237,936	13	....	III to V—Strong.
20	18.60 18.65	18.62	.0	182,177	182,530	77.5	77.7	109.3	2,350	—1,547	7.157	1,303,888	1,989	1,305,877	13	49	XII—Light.
20	....	....	....	182,177	....	77.5	....	....	2,350	....	*a* 6.655	*a* 1,212,410	1,989	1,214,399	12	....	XII to V—Nearly calm.
21	18.60 18.60	18.62	.0	180,685	181,088	76.9	77	109.5	2,350	—1,492	7.477	1,351,069	*c* 2,026	1,353,095	13	40	XI—Light.
21		....	....	180,685	....	76.9	....	....	2,350	....	*a* 6.736	*a* 1,217,069	*c* 2,026	1,219,095	11	....	XI—Very light.

24........	18.30 18.25	18.30	—.1	186,092	187,196	79.2	79.7	108.5	2,350	+4,104	6.948	1,293,000	1,926	1,294,926	18	49	IX—Calm to light.
24........	....	....	....	186,092	....	79.2	....	....	2,350	....	*a* 6.481	*a* 1,206,008	1,926	1,207,934	11	....	VII—Light.

a Float observations; all others meter. *b* River very rough. *e* Interpolated from preceding and following days.

NOTES.—The discharge section was located about 1½ blocks above Carrollton avenue and at same place as in former years.

The United States engineer gauge is at the discharge section and its readings are tabulated; those in the first column are from the regular gauge observer's reports taken daily at 8 a. m. and 4 p. m.; the change in twenty-four hours is derived from this column; the "local" readings are from the same gauge, but taken by the discharge party and are means of readings during time of discharge observations.

The datum line is taken at 18.77 feet on the gauge as observed May 18, 1897.

ST. FRANCIS RIVER.

U. S. ENGINEER.

1896.																	
Nov. 16........	*a* 7.1	1	—0.8	1,576	1.576	8.8	8.8	5	409	....	0.555	874	....	....	8	32	Calm.
17........	6.9	.90	—.2	1,520	1,561	3.7	3.8	5	408	—15	.505	768	....	....	9	32	XII—Very light.
17........	6.9	.95	....	1,530	1,551	8.7	8.8	5	408	—10	*b* .658	*b* 1,007	....	....	14	32	Do.
17........	6.9	.95	....	1,511	1,532	8.7	8.7	4.9	408	—19	*b* .545	824	....	....	15	32	XII—Light.
17........	6.9	.95	....	1,580	1,551	8.8	8.8	4.9	408	+19	*b* .661	*b* 1,012	....	....	14	32	XI—Very light.

a Helena gauge, whose zero is 161.98 feet above the Cairo datum plane. *b* Velocities were observed with floats; all others were with meter.

NOTES.—The discharge section is about 15 miles above the mouth of the St. Francis River. Local gauge not connected with the Cairo datum. Datum line is taken at 10 feet on the local gauge as observed November 16.

The Haskell meter was run at six-tenths depth for from three to five minutes. The float ranges were 50 feet apart; lower float run at mid-depth. Soundings were taken with a pole. For additional description of methods see page 3661.

WHITE RIVER.

U. S. ENGINEER.

1896.																	
Nov. 27........	*a* 13.5	1.25	—0.1	7,017	7,266	13.8	14.2	17.6	508	....	1.235	8,664	....	....	10	39	XII—Brisk; rain.
28........	13.5	1.55	.0	7,184	7,281	14.1	14.3	17.9	510	+ 15	1.415	10,168	....	....	10	19	XII—Strong.
28........	13.5	1.58	....	7,097	7,178	13.9	14.1	17.6	510	—103	1.394	9,893	....	....	10	19	Do.
28........	13.5	1.64	....	7,164	7,215	14	14.1	17.6	510	+ 37	*b* 1.591	*b* 11,398	....	....	10	19	XII—Mild.
28........	13.5	1.65	....	7,081	7,127	13.9	14	17.6	510	— 88	*b* 1.726	*b* 12,221	....	....	10	19	XII—Strong.
28........	13.5	1.67	....	7,110	7,146	13.9	14	17.6	510	+ 19	1.451	10,320	....	....	10	19	Do.
28........	13.5	1.70	....	7,116	7,136	14	14	17.6	510	— 10	1.475	10,493	....	....	10	19	XII—Light.
28........	13.5	1.72	....	7,124	7,134	14	14	17.6	510	— 2	1.472	10,486	....	....	10	19	Do.
28........	13.5	1.73	....	7,116	7,121	14	14	17.6	510	— 13	*b* 1.593	*b* 11,336	....	....	10	19	Do.
28........	13.5	1.74	....	7,060	7,060	13.8	13.8	17.6	510	— 61	*b* 1.614	*b* 11,395	....	....	10	19	Do.

a Mouth of White River gauge, whose zero is 128.73 feet above the Cairo datum. *b* Velocities were observed with floats; all others were with meter.

NOTES.—The discharge section is about 16 miles above the mouth of White River and 8 miles above cut-off (mouth of Arkansas River). Datum line is taken at 1.74 feet on the local gauge as observed November 28. Local gauge not connected with the Cairo datum. For additional description of methods see page 3661.

Results of discharge observations—Continued.

ARKANSAS RIVER.

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard.	Local.	Rise or fall in the preceding 24 hours.	Area.		Depth.			Width.								
				Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1896.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*			
Nov. 30	a 13.6	1	—0.2	2,549	....	4.8	....	7	526	....	2.083	5,309	....	....	7	19	I—Brisk.
30	13.6	1	....	2,573	....	4.9	....	7.1	526	....	2.109	5,426	....	....	7	19	Do.
Dec. 1	13.3	1.10	— .3	2,599	....	4.8	....	7.1	537	....	b 2.327	b 6,046	....	....	10	19	I—Light.
1	13.3	1.12	....	2,615	....	4.9	....	7.2	537	....	b 2.248	b 5,878	....	....	10	19	Do.
1	13.3	1.15	....	2,645	....	4.9	....	7.1	537	....	2.140	5,681	....	....	7	19	Do.
1	13.3	1.19	....	2,670	....	5	....	7.2	537	....	2.142	5,719	....	....	10	19	I—Very light.
1	13.3	1.22	....	2,640	....	4.9	....	7.2	537	....	2.163	5,709	....	....	10	19	Do.
1	13.3	1.25	....	2,690	....	5	....	7.2	540	....	2.265	6,092	....	....	10	19	Do.
1	13.3	1.27	....	2,684	....	5	....	7.2	540	....	b 2.265	b 6,079	....	....	10	19	I—Mild.
1	13.3	1.30	....	2,706	....	5	....	7.2	540	....	b 2.180	b 5,901	....	....	10	19	Do.

a Mouth of White River gauge, whose zero is 128.73 feet above the Cairo datum plane.

b Observed with floats; all others were with meter.

NOTES.—Discharge section was at Hopedale Landing, Ark., about 18 miles above mouth of Arkansas River and about 5 miles above the cut-off. Local gauge zero is 144.90 feet above the Cairo datum. Soundings taken with pole, 25 feet apart.

YAZOO RIVER.

STANDARD.

1896.																	
Dec. 12	a 3.5	10.03	—0.1	4,489	....	13.5	....	17.8	332	....	1.108	4,975	....	....	7	25	VI—Very light.
12	3.5	10.06	....	4,488	....	13.5	....	17.8	332	....	1.095	4,912	....	....	13	25	V—Very light.
12	3.5	10.08	....	4,464	....	13.4	....	17.8	332	....	1.060	4,732	....	....	4	13	Do.
12	3.5	10.12	....	4,538	....	13.7	....	17.8	332	....	1.116	5,063	....	....	7	13	Do.
12	3.5	10.14	....	4,515	....	13.6	....	17.8	332	....	1.130	5,104	....	....	7	15	Do.
12	3.5	10.15	....	4,538	....	13.7	....	18	332	....	1.086	4,928	....	....	7	15	Do.
12	3.5	10.16	....	4,543	....	13.7	....	18	332	....	1.092	4,963	....	....	7	15	V—Nearly calm.
12	3.5	10.17	....	4,580	....	13.8	....	18	332	....	1.030	4,718	....	....	7	15	Calm.
12	3.5	10.18	....	4,565	....	13.7	....	18	332	....	b 1.237	d 5,645	....	....	13	13	Do.
12	3.5	10.19	....	4,537	....	13.7	....	17	332	....	b 1.293	d 5,865	....	....	7	15	Do.

BLACK RIVER.

STANDARD.

1896.																	
Dec. 18	a 16.4	9.68	—0.5	10,874		20.4		29.2	532		0.922	10,023			8	20	XII—Brisk.
18	16.4	9.66		10,785		20.3		29.1	531		.947	10,208			8	20	Do.
18	16.4	9.64		10,761		20.3		29.1	531		.902	9,707			8	20	XII—Mild to brisk.
18	16.4	9.62		10,756		20.3		29	531		.929	9,994			8	20	XII—Mild.
18	16.4	9.60		10,734		20.2		29	531		.956	10,264			8	20	Do.
18	16.4	9.56		10,726		20.2		29	531		.915	9,810			8	20	Do.
18	16.4	9.53		10,744		20.2		29	531		.895	9,620			8	20	Do.
18	16.4	9.50		10,761		20.3		29	531		.933	10,042			8	20	Do.
18	16.4	9.47		10,779		20.3		29	531		b 1.199	b 12,927			12	20	XII—Light.
18	16.4	9.45		10,774		20.3		29	531		b 1.179	b 12,705			12	20	Do.

a Barbre Landing gauge, whose zero is 24.17 feet above the Cairo datum.

b Observed with floats; all others were with meter.

NOTES.—The discharge section is 2 miles above mouth of Black River and about 32 miles from mouth of Red River. It is about 150 meters below Davids Landing, La. The zero of local gauge is 30.96 feet above the Cairo datum. For additional description of methods see general notes, below.

RED RIVER.

U. S. ENGINEER.

1896.																	
Dec. 19	a 15.7	10	—0.6	5,962		15.1		21	394		b 1.797	b 10,714			8	15	Calm.
19	15.7	9.98		5,940		15.1		21	394		b 1.702	b 10,110			8	15	Do.
19	15.7	9.96		5,930		15.1		21	394		1.653	9,804			8	15	Do.
19	15.7	9.94		5,950		15.1		21	394		1.585	9,430			8	15	Do.
19	15.7	9.93		5,927		15		20.8	394		1.629	9,654			8	15	II—Very light.
19	15.7	9.91		5,917		15		21	394		1.642	9,715			8	15	Do.
19	15.7	9.88		5,937		15.1		21	394		1.602	9,510			8	15	I—Very light.
19	15.7	9.85		5,927		15		21	394		1.609	9,539			8	15	Do.
19	15.7	9.82		5,893		15		21	394		1.556	9,169			8	15	Do.
19	15.7	9.80		5,892		15		21	394		1.584	9,334			8	15	Do.

a Barbre Landing gauge, whose zero is 24.17 feet above the Cairo datum plane.

b Observed with floats; all others were with meter.

NOTES.—The discharge section was about 32 miles above the mouth of Red River and 2 miles above the mouth of Black River. It was in a long, straight reach, about 200 meters above Joffrions Landing, La. The zero of local gauge is 30.60 feet above the Cairo datum.

GENERAL NOTES.—OBSERVATIONS ON THE TRIBUTARIES, LOW WATER, 1896.

The following methods were employed in measuring the low-water discharges of the tributaries, except where otherwise noted:

The floats used were double floats, the lower one being run at mid-depth. Float ranges were 100 feet apart.

The Haskell meter was used, and was suspended from a boom at the stern of a skiff. The skiff was held in position by a wire stretched across the river. The distance apart of the velocity stations was generally 25 feet, and soundings were 12½ feet apart. The meter was held at six-tenths depth, and was generally run for two hundred seconds at each station.

Values of meter constants are given at the end of discharge tabulations. (See p. 3662.)

NOTE.—The floats used in measuring these river discharges are of the kind k as double floats, and consist of a surface float and a submerged float, the latter suspended to the former by a string, the length of which is adjusted according depth of water, so that the lower float will be at mid-depth.

The surface float was an air-tight buoy made of galvanized sheet iron, circu plan, and elliptical in cross section, its major axis being about 10 inches, and axis about 5 inches. On top of this was fastened a small wooden stick ab inches high, bearing a small double flag (red and white or red and black). C bottom of said float was a small hook, to which was fastened a small twine s which supported the subsurface float, which, for high water, was a shee cylinder about 6 inches in diameter and about 12 inches high, the string fastened by a wire bail to the cylinder. Said cylinder resembles a bottomless b

For low water, a subsurface float was used, which consisted of 2 sheets of g ized iron 12 by 15 inches, fastened perpendicular to each other, forming in cross, thus +.

Crevasses of 1897, Mississippi River, below Vicksburg, Miss.

Locality.	Distance below Cairo, and bank.	Date of break.	Date of measurement.	Width.	Discharge per second.	Gauge rea	
						At date of break.	At me
	Miles.	1897.	1897.	*Feet.*	*Cu. feet.*	*Feet.*	
Biggs	604 R	Apr. 16	Apr. 17	1565	146, 825 *a* 121, 119	*b* 52. 4	
Reeds *c*	605 R	Apr. —	....	....	....	....	....
Glasscocks	725. 5 R	Apr. 17	Apr. 20	860	49, 429 *a* 51, 195	*d* 49. 6	
Conrad	840. 5 L	May 30	May 31	241	24, 718 *a* 21, 120	*e* 38. 5	

a Float observation; others were with the Haskell current meter.
b Vicksburg gauge.
c Not measured. A single surface float was used; it was a block of wood about 2¼ feet lon feet at largest diameter, roughly rounded; a 100-foot line was fastened to it to measure its run
d Natchez gauge.
e Baton Rouge gauge.

This list does not include breaks at Baton Rouge, which were promptly clos

Results of final reduction of rating observations, Haskell current meter.

No. of wheel.	Date.	Constants.		No. of observations.	Length of base.	Limits of observed velocity.	Locality
		a	*b*				
					Feet.	*Feet per sec.*	
2	April 21, 1896	1. 81466	0. 08382	32	200	1. 34 to 7. 02	Crofton Lake,
	February 9, 1897 *a*	1. 8816	. 0708	30	200	. 80 to 10	Horn Lake, T
	April 29 to 30, 1897 *a*	1. 88322	. 1187	28	200	. 63 to 11. 11	Moreau Bayou
6	April 21, 1896	1. 20262	. 043	30	200	. 63 to 5. 63	Crofton Lake,
	February 9, 1897	1. 2603	. 0851	30	200	. 47 to 4. 88	Horn Lake, T
	Weighted means *b*	1. 21694	. 06205				
6	April 21, 1896	1. 0886	. 16415	10	200	. 63 to 1. 7	Crofton Lake,
	February 9, 1897	1. 1376	. 18566	20	200	. 47 to 2	Horn Lake, T
	Means *c*	1. 1131	. 1749				

a February 9, 1897, was used for discharges prior to March 5, 1897, and April 29 to 30 for those quent to that; the wheel being injured by drift March 5, 1897.
b These values used for all tributary discharges except St. Francis and for those of main river wheel No. 6 was employed.
c These values, derived from low velocities, used for reduction of discharges on the St. Francis where the velocity was much less than 1 foot per second.

NOTE.—Results of ratings of May 25, 1897, were used for discharges from M a new vane being put on meter that day. They are as follows: Wheel No. 1.84174, b=0.48835; Wheel No. 6 (used for low velocities), a=1.06145, b=0.5713

GAUGE INSPECTION.

The regular gauges, which are in charge of the secretary of the Commission, were inspected three different times during the year by the party on the steamer *Search*. The necessary repairs were made to the gauges and bulletins at each inspection. No material change was made in the location of gauges, except Mhoons Landing, which was moved upstream about 325 meters, owing to caving banks.

The necessity of frequent inspections of the gauges where reliable results are important has long been apparent, and the small corrections to the observers' gauge readings required during the past year may be fairly credited to the increased number of inspections.

In this connection it may be well to again call attention to the desirability of having all of the gauges on the Mississippi River placed under the control of the secretary of the Mississippi River Commission. The cost of inspection of such gauges below the Ohio River would be but slightly in excess of the cost of inspection of the gauges already under the Commission, as the inspector passes them at each inspection trip.

In view of the many conflicting reports from different stations during the last great flood, it seems important and desirable that the Weather Bureau and the Engineer Department should obtain their readings from the same gauges. Where different gauges are read, the reports which go to the public through the daily press are very confusing and require considerable explanation in order to make them comparable with readings of former years. An arrangement could easily be made to have one standard gauge at each gauge station, and all others should be eliminated.

HIGH-WATER GAUGES.

These gauges were set during the early spring of 1896, and the leveling to them was completed during the summer. They were set rather hastily in anticipation of a spring flood in 1896, but the stage did not reach sufficient height to register on these gauges.

There are 182 of these gauges, set at intervals of about 5 miles, between Cairo, Ill., and Fort Jackson. They are all set so as to read elevation above the Memphis datum. While they are made so as to be self-recording as far as the maximum stages reached are concerned, volunteer observers have been secured to read them daily for a short time each side of the maximum, and also to mark, in some permanent way, the highest point reached by the flood.

By this means a good, reliable record of the late flood has been obtained, and the new flood line is doubtless much better determined than that of any previous flood. Many of the observers were driven out by the flood, and the self-recording gauges kept their own record. Great credit is due the observers, who continued their readings under many difficulties, sometimes at considerable expense, and all without compensation.

The self-recording gauge is described in the report of 1896, page 3535, as follows:

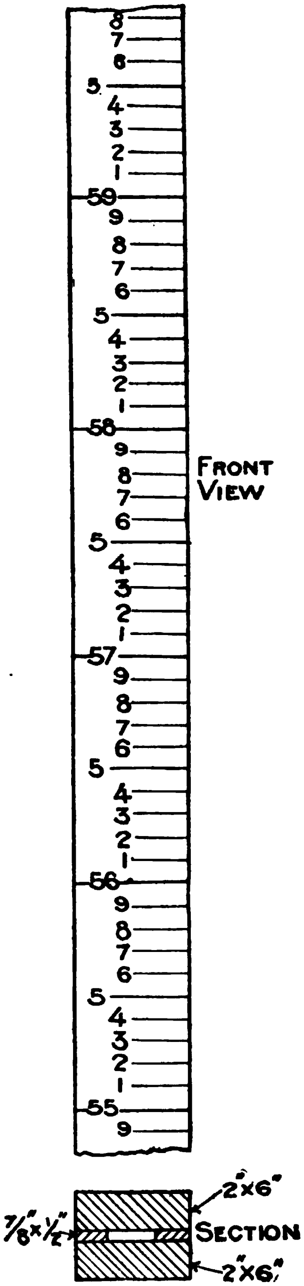
"In order to check the work of the observers and to obtain an automatic independent record of the maximum height reached by the water, a special form of gauge was designed by J. A. Ockerson. It consists, essentially, of a long, shallow box, the face of which is graduated to feet and tenths, similar to the ordinary gauge. The inside of the box or open space between the front and back of gauge is half-inch by 4 inches, and is freely coated with a soluble paste or wash. The gauge is set upright, with the lower end open for the free access of water, and the upper end is closed to prevent the rain from entering. The water enters the lower end as it rises; the small opening prevents the wave wash, and when the lower end is well submerged the water in the box will be comparatively still. The maximum reached will be shown by the mud stains and the lower limit of the paint left intact."

A sketch of this form of gauge is shown in diagram page 3664:

A special party was sent out at the top of the flood on the steamer *Vidalia*, in charge of Mr. E. D. Jones, to obtain the maximum readings of the high-water gauges between Cairo and Lake Providence. The other high-water gauges were read by the party on the steamer *Search* en route between discharge stations.

THE FLOOD OF 1897.

The height reached by the flood of 1897 at nearly all of the gauge stations below Cairo exceeded that of any known record of previous years. The water which contributed to the volume which finally culminated in one of the greatest floods known, came largely from the Ohio and its tributaries, which were all swollen by extraordinary rains. Fortunately the tributaries entering the Mississippi below Cairo



HIGH WATER GAUGE.

were all rather below the medium stage when the flood wave passed them. But even without their flood contributions, which are often coincident with those of the Mississippi, the high-water line was pushed up considerably above any previous records from below New Madrid, Mo., to Fort Jackson, La.

The height of the flood between Point Pleasant, Mo., and Memphis was doubtless increased by the levee system along the St. Francis front, most of which, for the first time, became a factor in the problem of flood control.

This levee system has been extended from Point Pleasant, Mo., to Pecan Point, a distance of about 117 miles by river, the greater part of the line having been constructed since the high water of 1893.

The unusual height reached by the flood between New Madrid, Mo., and Memphis jeopardized the lives of the inhabitants and prompt relief became imperative. The steamers *Minnetonka* and *Vidalia* were put in commission on March 21, in accordance with telegraphic orders from the honorable Secretary of War. The necessary subsistence stores were furnished by the city of Cairo for the use of the flood sufferers. These steamers patrolled the flooded district for seven days and rescued 145 persons, with their household effects, cattle, and other stock.

The stage at Cairo reached the maximum, 51.6 feet, on March 25. This was 0.6 foot below the maximum of 1883. At Cottonwood Point, 123 miles below Cairo, the flood stage of March 22, 1897, exceeded that of 1883 by 1.5 feet.

The breaks in the levee at Caruthersville on March 18, and at Lintdale and Midway on March 24, prevented the flood from reaching a higher stage. Had the levee continued to confine the water up to the maximum, it is probable that the stage at Cottonwood Point would have been about 3 feet above the maximum of 1883.

The rise at Fulton, Tenn., was checked by numerous breaks in that locality, and reached a stage only 0.3 foot higher than the previous highest record.

The St. Francis levee system terminates at Pecan Point, a distance by river of about 35 miles above Memphis. From Pecan Point to Helena, a distance by river of about 110 miles, no systematic line of levee exists, and practically the whole extent of this river front is exposed to the floods. There are detached stretches of levee which are of considerable local value as protection from ordinary overflow stages.

Memphis lies directly opposite this large, comparatively open basin. The maximum stage reached at Memphis in 1897 was 37.7, or 2.1 feet higher than any previous record.

At Mhoons Landing the river reached a stage of 41.6 feet on April 4, or 1.4 feet higher than any previous record at this station.

At Helena, Ark., the river reached a stage of 51.8 on April 4, when the breaks at Flower Lake, Williamsons, and Hubbards occurred, and the river fell 1.4 feet in one day. The highest previous record was 48.1 feet and occurred in 1886. The 1897 record, therefore, exceeds the highest previous record by 3.7 feet.

The rise in the St. Francis basin at the St. Louis, Iron Mountain and Southern bridge reached its highest point on April 5, when it read 41.6, or 0.5 higher than in 1893, and had risen only a tenth of a foot during the preceding day. It is therefore probable that the stage at Helena was within a few tenths of a foot of the height that would have been reached with the levees intact. Such maximum would have been very close to 52 feet.

At Sunflower Landing the river reached its maximum at 47.3 on March 27. The highest previous record was 43 feet in 1893, or 4.3 feet lower than the flood of 1897.

Prior to March 27 the levees along the White River front had been broken in eight different places above Sunflower Landing. The levees had also been overtopped by the flood in many places.

At the mouth of White River the maximum stage, 52.4, was reached on March 29. This is just 2 feet higher than the previous maximum record made in 1890. Several breaks had occurred in the White River front levees prior to the above date. Two breaks occurred on the Mississippi side about 20 miles above the mouth of the White River on March 29 and 30. The record for 1897 is therefore considerably below what it would have been with the levees intact.

The extent of the backwater up the White and Arkansas rivers was determined by Recorder E. D. Jones on the steamer *Vidalia*. The backwater extended up the White River to Casscoe Landing, about 20 miles below Clarendon and about 114 miles by river from the Mississippi River. At this point the water was found to be about 1.2 feet below the high water of 1890. At St. Charles Landing, about 80 miles from the mouth of the river, the water was said to be even with the high-water mark of 1890. It was reported here that the Modoc crevasse raised the river 1¼ feet and the Williamson and Hubbard crevasses gave about 0.3 foot more. These statements could not be verified and are not considered as reliable.

At Indian Bay Settlement, about 75 miles from mouth of White River and 18 miles in a straight line from Modoc on the Mississippi River, the land was about 2 feet above overflow until the levees broke below Helena. The settlers reported that the

Modoc break gave them about 8 feet of water, Westover break about 5 inches, the Williamson and Hubbard breaks about 2 feet more. The water finally ca a stand at a stage about 5 inches above the high water of 1890. On the da inspection, April 14, the land was submerged several feet deep.

The backwater extended up the Arkansas River about 116 miles by river abo mouth. At Red Fork the water reached 170.2 feet above the Memphis datu gauge at Station 0 of the Mississippi River Commission levees. This is abou feet above the high water of 1890 at same point.

The maximum stage at Arkansas City was reached on March 29, and read on the gauge. This was 1.6 feet higher than the previous highest record, w occurred in 1893. The levees on the White River front and two points on the sissippi side broke prior to this date. The levees were also awash in several pl

At Greenville the maximum was also reached on March 29, at a height of 46.8 on the gauge, or 2.5 feet higher than the greatest previous record, which occurr 1893. The Mississippi levees were held intact through the flood of 1893, but Arkansas levees below Arkansas City gave way in several places. In 1897 the ditions were reversed—three breaks occurred in the Mississippi levees from Arkansas City to Vicksburg, while the Arkansas levees in the same stretch rema intact.

The Deerfield break below Greenfield, checked the rise at a point consider below the maximum that would have been reached with the flood fully confine

At Lake Providence the maximum was reached on March 30, at a reading of on the gauge. This was 2.5 feet above the highest previous record, which was in 1892.

At Vicksburg the river reached 49.4 feet on April 1. This was the maximu the water coming down the river proper. The river fell slightly until Ap when it began rising again from the water coming through the crevasses at the of about 250,000 cubic feet per second, and returning to the river by way o Yazoo bottoms. This rise continued steadily for ten days and reached a heig 52.4 feet on the gauge, when it was checked by the break in the Biggs levee, a 4 miles below Vicksburg.

The maximum reached in 1897 was 3.4 feet above the highest stage of 1890, w is the highest previous record since 1872. In 1862 the stage is reported to reached 51.1 feet.

When the crevasse occurred, the river was rising at the rate of 0.3 foot per and the fall after the crevasse occurred was very slow and did not amount to 1 until May 7, or some twenty-one days after the levee broke.

The conditions at Vicksburg are very similar to those at Helena except that was no halt in the rise at the latter point.

At St. Joseph, La., the maximum was reached at 47.8 feet on the gauge on 17, and remained above 47 feet for a period of twenty-four days. The maximu 2.6 feet higher than the previous maximum, which occurred in 1890.

At Red River Landing the river reached the highest point on May 9, when it 50.2 feet on the gauge, or 1.3 feet higher than the highest previous record, w occurred in 1892.

The Red River itself was about 20 feet below the maximum stage and fa when the Mississippi River was at its highest point.

At Bayou Sara the river reached a stage of 43.8 on May 14. This is 1.5 feet h than the highest previous record, which occurred in 1892.

At Baton Rouge the maximum stage was reached on May 15, when it read 40. the gauge. This is 2 feet higher than the previous maximum of 1892.

At Plaquemine the river came to a stand on May 13, at a stage of 36.25 feet o gauge. This is 2.4 feet higher than the highest previous record, which occ in 1892.

At Donaldsonville the river reached a stage of 32.85 on May 13. The hi previous reading on this gauge, which was established in 1890, was 30.6 feet, feet lower than the maximum of 1897.

At College Point the river reached its highest stage at 27.95 on May 15. T 2.1 feet higher than the previous maximum, which occurred in 1893.

At Carrollton the river reached a stage of 19.05 on May 13. This is 1.6 feet a the highest previous record, which was made in 1893. At this point the stage above the highest previous record for a period of 23 days—to May 5.

From Red River Landing to New Orleans the levees remained practically i and the whole volume passing the Atchafalaya flowed down between the l without loss of any magnitude.

A hydrograph (plate 11) has been prepared showing the stage at each gauge tion below Cairo for the period January to May, inclusive, 1897.

One very peculiar feature in this hydrograph is the uniformity in the rise at stations below Helena through the month of March. It will be seen that the hy graph at each station is nearly a straight line up to the point where it is mod by crevasses. The lower end of this straight line begins at about the bank-full stage, and its regularity above that point is doubtless due to the control exercised by the levees in confining the flood. It suggests that the complete control has been carried up to a higher point than heretofore, which accords well with the fact in the case.

Table No. 6 gives the highest readings recorded each year sine 1872 at each of the gauge stations below Cairo. This table shows that the flood of 1897 gives the highest record at all points below New Madrid, Mo.

The following tabulation shows the maximum stage reached at each regular gauge and each high-water gauge between Cairo, Ill., and Fort Jackson, La., during the flood of 1897.

TABLE NO. 5.

Elevation in feet above Memphis datum of the maximum stage of the flood of 1897 at about 5-mile intervals between Cairo, Ill., and Fort Jackson, La. Distances are taken from the inch-mile charts.

TABLE NO. 5.—*Elevations of maximum stage during flood of 1897, Cairo, Ill., to Fort Jackson, La.*

Name of gauge.	Distance from Cairo.	Highest reading.		Maximum elevation of flood above Memphis datum.	How determined.
		Date.	Gauge reading.		
	Miles.	1897.	*Feet.*	*Feet.*	
Cairo	0.0	Mar. 25, 26	51.62	329.33	Read.
182	4.4	Mar. 27		326.5	Do.
181	8.9	Mar. —		325.3	Mud stains.
180	12.5	Mar. 28		324.2	
179	17.8	Mar. —		321.4	
Belmont	21.8	Mar. 28–30	45.08	318.80	Read.
178	27.5	Mar. —		316.5	Mud stains.
177	33.5	Mar. 28		314.2	Read.
176	38.5	do		312	Do.
175	44.8	Mar. 26		309.7	Do.
174	49.8	Mar. 29		308	Do.
173	54	do		306.9	Do.
172	59.5	do		306.4	Do.
171	64.5			304.9	Mud stains.
New Madrid	70.8	Mar. 29	40.27	302.86	Read.
170	73.8	do		300.8	Do.
169	78.7	Mar. —		298.8	Do.
168	84.8	Mar. 29		296.8	Do.
167	89.5	do		293.1	Do.
166	95			289.9	Mud stains.
165	99.8	Mar. 29		288	Read.
164	103.8	Mar. 30		286.4	Do.
163	109.8	Mar. 29		283.8	Do.
162	113.5	Mar. 21–30		281.2	Do.
161	118.5	Mar. 30		278.8	Do.
Cottonwood Point	123	Mar. 21–23	39.36	276.85	Do.
160	127.5	Mar. 21		275.7	Do.
159	130.5	Mar. —		274	Mud stains.
158	135	Mar. 21		273	Read.
157	139.8	Mar. 22		270.8	Do.
156	146	Mar. —		268.1	Mud stains.
155	152.8			264	Do.
154	158.3			261.4	Do.
153	161.8	Mar. 18		260.2	Read.
152	167.5	Mar. 20		258.3	Do.
151	172.8			254.8	Mud stains.
Fulton	175.4	Mar. 23	37.5	252.87	Read.
150	180.1			251.2	Mud stains.
149	186.8	Mar. 22–28		247.5	Read.
148	192.8			245.7	Mud stains.
147	197.8	Mar. 23		243.8	Read.
146	203.3			240.1	Do.
145	208	Mar. 22		238.4	Do.
144	212.8			235.5	Mud stains.
143	220.8			233.8	Read.
142	225.5			229.3	Mud stains.
Memphis	230	Mar. 20	37.75	228.59	Read.
141	235	Mar. 19		225.1	Do.
140	239.5			222.9	Do.
139	244.8			221	Do.
138	249.5	Apr. 1		218.2	Do.
137	256.8	Apr. 4		215.4	
136	261.3	do		213.6	
135	266.8	do		211.8	

TABLE NO. 5.—*Elevations of maximum stage during flood of 1897, etc.*—Continue

Name of gauge.	Distance from Cairo.	Highest reading.		Maximum elevation of flood above Memphis datum.	How det mined
		Date.	Gauge reading.		
	Miles.	1897.	*Feet.*	*Feet.*	
134	271	Apr. 4		210.8	
Mhoon	277.3	do	41.60	209.95	Read.
133	280.5	do		209.5	Do.
132	284.5	do		207.6	
131	289.5	do		206.6	
130	293.5	do		205	
129	297.8	do		204.6	
128	301.5	do		203.2	
Helena	306.5	do	51.75	200.6	Do.
127	312.5	do		197.5	Do.
126	317.8	do		195.2	Mud stain
125	323.5	do		193.2	Do.
124	329.3	do		190.9	Read.
123	334.5	do		189.4	Do.
122	339	do		185.8	Do.
121	342.5			184.8	Mud stain
120	346.8			183.1	Do.
Sunflower	352.7	Mar. 27	47.17	181.12	Read.
119	357	do		179.5	Do.
118	362	do		178.5	Do.
117	366.8	do		176.5	Do.
116	371.8			175.1	Mud stain
115	378			172.5	Read.
114	383.5	Mar. 29		170.4	Do.
113	389.5	do		169.3	Do.
White River	393.2	do	52.42	168.02	Do.
112	398.5			166.23	Do.
111	401.8	Mar. 29		165.3	Do.
110	408	do		164	Do.
109	412	do		162.9	Do.
108	416.8			162.4	Do.
107	421.5			160.6	Mud stain
106	427			159.7	Do.
105	432.5	Mar. 30		157	Read.
Arkansas City	438.3	Mar. 29	51.9	155.21	Do.
104	444.8	do		152.4	Do.
103	449.5	Mar. 30		151.6	Do.
102	456.5	do		148.6	Do.
101	459			148.2	Do.
100	463.5			147.3	Mud stain
99	467			147	Do.
98	473.3			144	Do.
Greenville	478.3	Mar. 28	46.75	141.62	Read.
97	482.5			140.5	Do.
96	487	Mar. 28		139.7	Do.
95	489.8	Mar. 29		138.6	Do.
94	495.3			136.9	Mud stai
93	501			134.8	Do.
92	505.5	Mar. 29		133.8	Read.
91	510.5	do		131.2	Do.
90	517	do		129	Do.
89	522.5	do		127.6	Do.
88	525.8			125.8	Mud stai
87	531.5	Mar. 29		123.8	Read.
86	537.5	do		122.3	Do.
Lake Providence	542.3	Mar. 30	44.4	120.89	Do.
85	546.5			119.9	
84	552.3			117.9	Do.
83	556.5	Apr. 17		116.43	Do.
82	561.3	do		115.40	Do.
81	568	do		112.2	Mud stai
80	573.5	do		110.9	Read.
79	578	Apr. 16		109.8	Do.
78	583.5	do		109.23	Do.
77	588.5	do		108	
76	593.5	do		106.95	Do.
Vicksburg	599.3	do	52.4	105.3	Do.
75	602.8	do		103.2	Do.
74	607.5	do		102.62	Do.
73	612.5	do		99.7	Do.
72	617.5	do		97.6	Do.
71	622	Apr. 17		96.5	Do.
70	627.5	do		94.69	Do.
69	633	do		92.4	Do.
68	638	Apr. 19		90.1	Do.
67	642.8	do		88.7	Do.
St. Joseph	648.3	Apr. 17	47.85	87.46	Do.
66	655.3	do		84.4	Do.

TABLE No. 5.—*Elevations of maximum stage during flood of 1897, etc.*—Continued.

Name of gauge.	Distance from Cairo.	Highest reading.		Maximum elevation of flood above Memphis datum.	How determined.
		Date.	Gauge reading.		
	Miles.	1897.	*Feet.*	*Feet.*	
65	659.8	Apr. 17		83.4	Read.
64	663.8	do		82.6	Do.
63	680.8	do		81.6	Do.
62	685.5	do		79.9	Do.
61	691.5	do		77.5	Do.
60	694	Apr. 19		76.2	Do.
Natchez	700.3	May 1–6	49.8	73.56	Do.
59	705.5	May 10		72.4	Do.
58	711.3	do		71.5	Do.
57	716	do		70.8	Mud stains.
56	720.5	do		69.3	Do.
55	725.3	May 11		68	Do.
54	731	May 12		66.3	Read.
53	737.5	do		65.4	Do.
52	742.8	May 13		64.3	Do.
51	747	do		63.6	Do.
50	751.5			63.2	Do.
49	756	May 14		62.3	Do.
48	761	do		61.5	Do.
Red River Landing	765.3	do	50.20	60.92	Do.
47	769	May 15		60	Do.
46	772.5	do		59.7	Do.
45	779.8	do		58.2	Do.
44	784.8	do		57.5	Do.
43	790.5	do		56.3	Do.
42	794.5	do		55.5	Do.
Bayou Sara	799.8	May 13–15	43.75	54.57	Do.
41	803.5	May 15		53.3	Do.
40	808	do		53.2	Do.
39	812.5	do		52.2	Do.
38	817	do		50.60	Do.
37	822.5	do		50.13	Do.
36	828.5	do		48.35	Do.
Baton Rouge	833.3	do	40.65	47.58	Do.
35	839.3	May 14		46.9	Do.
34	844.3	do		45.9	Do.
33	850	do		44.5	Do.
Plaquemine	854.1	May 13–17	36.25	44.18	Do.
32	859.8	May 14–18		43	Do.
31	864.5	May 13		42.1	Do.
30	869.3			41.3	Do.
29	874.5	May 12		40.7	Do.
28	880			40.1	Do.
Donaldsonville	885.4	May 16	32.88	39.22	Do.
27	889.8	May 15		38.9	Do.
26	895.8	do		37.6	Do.
25	900.3	do		36.7	Do.
College Point	904.5	do	27.95	36.06	Do.
24	910.5	do		34.7	Do.
23	914.8	May —		33.9	Do.
22	919.8	May 13		33.1	Do.
21	925.5	May 16		32	Do.
20	930.5	May 18		31.1	Do.
19	934.3	do		30.15	Do.
18	937.8	do		29.42	Do.
17	943.5	do		28.9	Do.
16	948	do		28.1	Do.
15	953	May 12		27.2	Do.
Carrollton	957	May 13	19.05	26.83	Do.
14	968	May 8		24	Do.
13	973.5	do		23.3	Do.
12	979.3	do		22.1	Do.
11	983.5	May —		21	Mud stains.
10	989.3	do		20.4	Read.
9	993	do		19.4	Mud stains.
8	999	do		19.1	Do.
7	1,003.8	Apr. —		18.1	Read.
6	1,008.3			17.4	Mud stains.
5	1,013			16.9	Read.
4	1,019	Apr. 20		15.9	Do.
3	1,023.8			15.5	Mud stains.
2	1,029	Apr. 17		14.8	Read.
1	1,034	Apr. 3		14	Read; high southeast wind.
Fort Jackson	1,039	Apr. 22 May 14	1.20	13.33	Read.

TABLE NO. 6.—*Showing the highest recorded stage each year at the various gauge stat on the Mississippi River below Cairo, Ill., since 1872.*

Year.	Cairo.	Belmont.	New Madrid.	Cottonwood Point.	Fulton.	Memphis.	Mhoons Landing.	Helena.	Sunflower Landing.	Mouth of White River.	Arkansas City.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1872	39.2	......	......	......	......	31.5	......	39.0	......	40.2	......
1873	41.6	......	......	......	......	32.5	......	40.0	......	42.9	......
1874	47.4	......	......	......	......	34.0	......	45.8	......	46.6	......
1875	45.1	......	......	......	......	33.1	......	42.4	......	45.0	......
1876	46.4	......	......	......	......	34.1	......	44.9	......	46.7	......
1877	40.5	......	......	......	......	32.1	......	41.8	......	44.6	......
1878	37.0	......	......	......	......	29.1	......	38.8	......	......	......
1879	36.5	......	......	......	......	28.1	......	37.3	......	......	......
1880	44.6	39.2	34.7*a*	35.5	34.2	33.4	36.1	43.7	40.6	46.6	45.1
1881	45.8	......	......	35.2	34.3	33.3	......	43.7	39.8	45.7	44.3
1882	51.9	44.8	......	37.5	36.7	35.2	39.8	47.2	41.7	48.4	47.1
1883	52.2	45.3	......	37.8	36.3	34.8	40.2	46.9	41.8	48.0	46.4
1884	51.8	45.8	41.5*a*	37.5	35.7	34.2	38.9	47.0	......	47.9	46.5
1885	39.0	36.1	31.5*a*	31.9	29.9	29.3	33.8	40.7	......	43.6	42.6
1886	51.0	44.6	40.4*a*	37.1	35.4	34.8	......	48.1	......	48.2	46.9
1887	48.5	43.0	37.8*a*	......	34.6	35.3	......	46.4	......	47.8	46.7
1888	45.4	41.1	36.0*a*	......	33.6	34.2	......	42.8	......	45.6	45.4
1889	34.5	31.4	27.5*a*	27.6	25.7	26.6	27.7	34.1	33.5	37.7	36.3
1890	48.8	43.0	38.2*a*	36.4	34.9	35.6	38.5	47.7	42.9	50.4	49.5
1891	46.2	41.3	36.4*a*	35.9	33.9	34.9	35.4	44.7	40.9	47.7	48.4
1892	48.3	43.1	37.7*a*	36.5	34.3	34.6	36.3	45.7	41.7	49.8	50.0
1893	49.3	43.8	38.1	36.6	34.6	35.2	37.9	47.9	43.0	49.5	50.3
1894	37.0	34.2	29.5	30.6	27.7	29.0	30.8	38.1	37.3	42.1	40.5
1895	33.0	30.4	26.0	26.4	23.1	24.1	25.4	31.3	31.1	34.4	32.5
1896	39.2	35.8	30.9	31.2	28.1	29.4	31.6	38.4	38.2	41.7	40.0
1897	51.6	45.1	40.3	39.3	37.5	37.7	41.6	51.8	47.3	53.4	51.9

Year.	Lake Providence.	Vicksburg.	St. Joseph.	Natchez.	Red River Landing.	Bayou Sara.	Baton Rouge.	Plaquemine.	Donaldsonville.	College Point.	Carrollton.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1872	35.2	39.5	......	39.9	39.4	......	29.7	......	......	......	12.3
1873	36.1	40.6	......	40.2	39.0	......	29.9	......	......	......	12.9
1874	37.4	45.7	......	45.6	47.1	......	36.2	......	......	......	15.7
1875	37.3	43.0	......	41.9	40.5	......	29.8	......	......	......	11.3
1876	38.0	44.9	......	43.9	45.4	......	33.4	......	......	......	12.7
1877	35.8	41.6	......	40.7	40.6	......	29.7	......	......	......	11.1
1878	35.8	41.0	......	39.2	......	......	29.4	......	......	......	11.3
1879	36.0	39.5	......	36.8	35.9	......	26.1	......	......	......	10.8
1880	38.1	43.2	......	43.5	44.1	......	33.2	29.0	......	21.3	13.9
1881	36.2	41.9	39.2	40.8	40.1	......	30.1	26.0	......	20.0	12.6
1882	38.3	48.8	44.9	47.8	48.5	......	36.0	31.3	......	23.2	15.0
1883	36.5	43.8	41.9	44.0	45.2	......	35.1	30.8	......	23.5	15.4
1884	38.4	49.0	45.0	47.4	47.8	......	36.2	31.7	......	24.1	15.6
1885	35.6	42.4	38.4	42.6	42.0	......	31.9	27.7	......	21.1	13.6
1886	37.9	44.2	......	43.8	41.9	......	32.1	......	......	......	13.8
1887	38.0	44.7	......	44.2	43.0	......	33.6	......	......	......	14.5
1888	38.1	44.2	......	43.4	41.8	......	32.5	......	......	......	14.7
1889	29.4	34.5	30.6	34.2	34.0	28.0	26.8	23.0	......	17.5	11.6
1890	41.1	49.1	45.2	48.6	48.7	41.2	36.6	31.9	......	23.9	16.1
1891	41.0	48.1	43.8	46.8	45.5	38.8	35.6	31.1	27.9	23.5	16.0
1892	41.9	48.5	44.6	48.1	48.9	42.3	38.5	33.5	30.2	25.6	17.4
1893	41.9	48.3	44.1	46.8	47.7	41.5	38.4	33.8	30.6	25.9	17.5
1894	34.4	40.9	36.9	40.6	39.5	33.1	31.0	26.8	24.4	20.6	13.5
1895	25.9	31.7	27.9	31.5	31.2	24.7	23.7	20.0	18.6	15.2	10.2
1896	33.8	39.0	35.2	38.2	37.4	30.7	28.9	25.1	23.1	19.3	13.7
1897	44.4	52.4	47.9	49.8	50.2	43.8	40.7	36.8	32.8	28.0	19.0

a Morrisson's gauge.

LEVEES AND CREVASSES.

The following table gives the location and size of crevasses in the levees between Cairo and mouth of Red River. The widths were measured with stadia; the average depth of water flowing through the breaks was estimated from depths measured at points in and near the breaks; the velocity was determined by timing surface floats, except at the Biggs break, where a meter was used. From these approximate data the approximate discharge was deduced.

TABLE NO. 7.—*Showing location, date of break, and size of the crevasses that occurred in the levees between Cairo and mouth of Red River during the flood of 1897.*

[Gauge readings are from regular gauge records.]

Locality.	Below Cairo.	Bank.	Date of break.	Date of observation.	Gauge readings.		Width.	Discharge per second.
					Name of gauge.	Reading.		
	Miles.					*Feet.*	*Feet.*	*Cu. ft.*
Caruthersville	111	R.	Mar. 18	Apr. 21	Cottonwood Point	36.8	3,050	18,300
Lintdale	125	R.	Mar. 24	Apr. 20	do	37	1,280	11,500
Midway	126	R.	do	do	do	37	1,350	12,200
Jno. B. Driver	165	R.	do	do	Fulton	35.8	310	2,800
Jas. D. Driver	167	R.	Mar. 20	do	do	35.8	865	7,800
Do	167½	R.	Mar. 19	do	do	35.8	520	4,700
Grider	167⅓	R.	do	do	do	35.8	370	3,300
Do	167⅓	R.	do	do	do	35.8	400	3,600
Pettys	168	R.	Mar. 24	do	do	35.8	390	3,500
Do	168⅓	R.	do	do	do	35.8	610	5,500
Do	168⅓	R.	do	do	do	35.8	295	2,600
Falls	177	R.	Mar. 14	do	do	35.8	50	....
Do	177	R.	do	do	do	35.8	200	....
Laniers	178	R.	do	do	do	35.8	175	1,000
Do	178	R.	do	do	do	35.8	365	2,200
Do	178½	R	do	do	do	35.8	290	1,700
Nodena	179	R.	do	do	do	35.8	125	700
Do	179	R.	do	do	do	35.8	230	1,400
Do	179	R.	do	do	do	35.8	350	2,100
Do	179⅓	R.	do	do	do	35.8	360	2,200
Do	179⅓	R.	do	do	do	35.8	1,590	9,500
Do	179⅓	R.	do	do	do	35.8	30	180
Do	179⅓	R.	do	do	do	35.8	50	300
Flower Lake	292	L.	Apr. 4	Apr. 17	Helena	47.4	2,020	73,000
Williamson	309	R.	do	do	do	47.4	1,320	39,600
Hubbard	312	R.	do	do	do	47.4	1,130	28,200
Westover	822	R.	Mar. 22	Apr. 16	do	47.6	730	5,000
Modoc	836	R.	do	do	Sunflower	44.4	1,305	23,400
Between Modoc and Hugheys	336⅓	R.	Mar. 23	do	do	44.4	765	9,200
Hugheys	337	R.	Mar. 22	do	do	44.4	430	3,000
Do	337	R.	do	do	do	44.4	335	2,300
Do	337	R.	do	do	do	44.4	320	2,200
Dixie Bayou	341	R.	Mar. 21	do	do	44.4	725	5,000
Schoolhouse Bayou *a*	343	R.	Mar. 20	Apr. 15	do	44	3,100	37,200
Wood Cottage	365	R.	Mar. 27	do	White River	51	1,560	37,500
Sledge	376	L.	Mar. 29	do	do	51	1,030	18,500
Sunnywild	380	L.	Mar. 30	Apr. 14	do	50.9	2,850	50,000
Stop	434	L.	do	Apr. 10	Arkansas City	49.9	1,520	45,000
Deerfield	493	L.	Mar. 28	Apr. 9	Greenville	44.6	1,240	40,000
Shipland	548	L.	Apr. 21	....	Lake Providence	43.6	1,100	....
Biggs	603	R.	Apr. 16	....	Vicksburg	52.2	1,565	147,600
Reed	604	R.	....	....	....	....	400	....
Glasscock	725	R.	Apr. 17	....	Vicksburg	52.2	860	50,000

a Cut by levee board.

PLANT AND OUTFIT PERTAINING TO SURVEYS, GAUGES AND OBSERVATIONS, AND MISSISSIPPI RIVER COMMISSION.

The steamer *Patrol*, survey boat *Illinois*, and fuel barge were used in the surveys of the upper river. They wintered at Lansing, Iowa, in charge of T. C. Hockridge. Only the minor current repairs were made, as the plant is in good condition.

The steamer *Search* has been kept in commission throughout the year on discharge work, gauge inspection, and in making low-water surveys in connection with dredging operations during the months of September and October.

A new mud drum and a new ice chest were put in during the summer and minor current repairs were made.

A new mud drum was put on the *Mississippi* and several defective sheets in boilers were replaced by new ones. A new filtering plant was put on board.

This steamer was cared for in winter quarters at East Cairo, Ky. After retur from the spring Commission trip she was laid up at St. Louis, Mo.

OFFICE REDUCTION AND PLATTING PERTAINING TO SURVEYS, GAUGES, AND OBSE TIONS.

Current gauge records were reduced, tabulated, and issued. The pamphle stages for 1896 was compiled and printed. Monthly reports of operations were pared and printed. Proceedings of the Commission, sixty-fourth to sixty-n sessions, were printed. Annual report of the Commission was proof read.

Colonel Stickney's paper on bank protection, with 35 plates, was printed.

Captain Waterman's report on dredging operations between Cairo and Mem during season of 1896 was printed.

Gauge hydrographs for the year 1896 were drawn. Biloxi tide records were parti reduced. Pilots' soundings on shoal crossings from St. Paul to Vicksburg in were compiled and tabulated, tracings were prepared showing controlling levee l below Cairo, and they were blue-printed.

Soundings of the low-water survey were platted from Baton Rouge to Donald ville. Nine hundred of these sections were platted. Areas of bank-full, medi and low-stage sections 1882–83 and 1895–96 were measured with planimeter and res were tabulated and platted.

Soundings of the season of 1895, Davenport and northward, were platted. field notes of the survey, Arnolds Landing northward to near Brownsville, Min distance by river of about 160 miles, were reduced and platted. The soundings the same reach were platted, and elevations and descriptions of high-water m and bench marks were deduced and tabulated.

Tabulations were also prepared showing discrepancies in levels and the sur slope of the river, all pertaining to the field season of 1896.

Profile and alignment of levees along the St. Francis and White River fronts part of the Upper Mississippi levee were platted and drawn.

Computations and reductions of high and low discharge measurements at var stations were made.

MAPPING AND PUBLICATION OF MAPS AND CHARTS.

The work of drawing the detail charts pertaining to the general survey of river has been continued. Charts 144, 145, 146, 147, 148, and 149, covering the r from Keithsburg, Ill., to Davenport, Iowa, were completed and printed. Charts 151, 152, 153, 154, 155, 156, and 157, pertaining to the work of 1895, Davenpo Arnolds Landing, have been projected, drawn, and nearly completed, except sc and index. Charts 70, 71, 72, and 76 were printed. Inch-mile sheet 26 was pleted and sheets 26, 27, and 28, Donaldsonville, La., southward, were prin sheets 119 and 120, from near Keithsburg, Ill., northward, were completed printed. Sheets 1 and 2 of the upper alluvial valley map, covering the river Cairo, Ill., northward about 450 miles, have been printed. The district map, C to the Gulf, showing the Engineer and Levee districts, the river and short port of the tributaries, controlling levee lines, and tables of distances, was drawn printed in color.

Four atlases showing the river from Cairo to the Gulf, scale 1: 20,000, were pared to show controlling levee lines and all works of improvement since orga tion of the Commission.

LOW-WATER SURVEY, VICKSBURG TO DONALDSONVILLE—COMPARISON OF CR SECTION ELEMENTS.

This work is a continuation of the low-water survey, Arkansas River to Vicksb which was made in the fall of 1894. The results of the comparisons of cross-sec elements of that portion of the river are given in the Report of 1896, pages 3 3598.

The objects of these surveys are to ascertain the amount and character of changes in bank lines and sections of the bed between the high-water banks have occurred since the first general survey of 1882–83.

The same general plan has been followed in the reduction of the field notes and comparison of the various elements as was used in discussing the results betw Arkansas River and Vicksburg.

A description of the field work of 1895–96 will be found in the Report for 1 pages 3533–3535.

There were 68,403 soundings taken in the survey of 1895–96, and consequently we have a like number of elevations of the bed from which the question of elevation or depression of the bed can be deduced. In addition to the soundings there were some 36,293 points located above water, most of which gave elevations in the bed of the stream on the bars between the high-water banks.

It may be said, therefore, that about 100,000 elevations of the river bed were determined between Vicksburg and Donaldsonville in the survey of 1895–96. This gives an average of about 365 elevations per mile of river that are connected with stable bench marks and are available for future reference. There are 1,118 cross sections of the river from one high-water bank to the other which have been analyzed in this discussion.

The first general survey of the river between Vicksburg and Donaldsonville was made during the winter of 1882–83. At that time numerous bench marks were established and their elevations above the datum were determined.

In the first reach, Vicksburg to Natchez, the sections sounded and used in this comparison averaged a distance of 390 meters (1,279 feet) apart. The Waterproof Cut-off occurred May 10, 1884, after the first general survey was made. About 15 miles of the river around the old bend is therefore omitted.

In the second reach, Natchez to Red River, the sections average 312 meters (1,023 feet) apart.

In the third reach, Red River to Scott Bluffs, the sections average 387 meters (1,269 feet) apart.

In the fourth reach, Scott Bluffs to Donaldsonville, the sections average 536 meters (1,759 feet) apart.

The river was divided into the reaches above named on account of the changes which occur in the physical conditions in the vicinity of Waterproof Cut-off, with river confined by levees on one side, above the mouth of Red River, due to its influence as a tributary, and the basin being open at the lower end, below the Red River, in consequence of its tributary effect with main river confined by levees on one side, and from Scott Bluffs down on account of the river being confined on both sides by levees and also being in the region of practically stable banks.

These features are so well defined that it was deemed best to treat each reach independently and then consider the entire distance as a whole. The survey was made after the great flood of 1882, which remained high until about August 1 and then fell steadily until about October 8. From Vicksburg to Natchez the stage averaged about 10 feet on Vicksburg gauge for two-thirds of the length. In the lower third of this reach survey was made on a rising stage, which reached 38 feet on the Natchez gauge at the close of the work. The survey of this reach was begun November 1, 1882, and completed February 22, 1883, except about 8 miles at the upper end, which was made about the middle of December, 1882.

From Natchez to Red River the survey was made between November 8, 1882, and January 17, 1883, at an average stage of about 12 feet on the Natchez gauge. From Red River to Bayou Sara the survey was made between January 17 and February 19, 1883, on a gradually rising stage ranging from 18.3 to 36.3 feet on the Natchez gauge. From Bayou Sara to Donaldsonville the survey was made from January 8 to March 17, 1883, at stages ranging from 14.5 to 31 feet on the Baton Rouge gauge. About two-thirds of the work ending at Donaldsonville was done on a rising stage.

The second survey, comprising the topography and hydrography between the high-water bank lines and levels, was made during the period from November 2, 1895, to January 10, 1896.

This leaves a period of about thirteen years between the two surveys, and during this time great changes occurred in the bank lines of the upper reach. The Waterproof Cut-off shortened the distance between Natchez and Vicksburg about 12.5 miles, and 4.5 miles of this distance was restored by the elongation of the bends. This shows that erosion was unusually active in this reach.

The survey of 1895–96 was largely made at a very low stage of river. The river from Vicksburg to Natchez, about 100 miles, and Fort Adams to Donaldsonville, about 130 miles, was surveyed at an unusually low stage; much of the time the stage was the lowest ever known.

Between Natchez and Fort Adams the survey was made during a rapid rise in the river. In ten days the river rose from 2.5 to 26 feet at Natchez. About 32 miles of river lying between Hutchins and Blackhawk was surveyed at a stage ranging from 16 to 27 feet on the Natchez gauge. In discussing this last reach a low-water line was assumed which coincides with the average low-water line of the work above and below this reach.

The relations existing between the stage and movement of sediment has an important bearing on these comparisons. It should therefore be remembered that the first survey was made just after one of the greatest known floods and a good share of it was on the rising phase of the next flood, which was also a great one; while the last survey was made just after two seasons of unusually low water, much being made during the lowest known stage. During the last survey there was or no slope in the river from Baton Rouge to Donaldsonville. Such sedime reached this section was necessarily deposited in the bed under these condition it may be swept out again by the next flood. This should be determined by an survey after the flood has subsided before any reliable conclusion as to perm changes in the bed can be reached.

The results shown in the subsequent tabulations are derived from comparin conditions at two different epochs, which are about 13 years apart. The differ found do not necessarily represent the resultant of all the changes that have place during that interval. They should, however, definitely mark any pers progressive change that has taken place. During the time elapsing between th surveys the conditions of the bed have doubtless varied widely in both direc from those found in either survey.

The river has been divided into stretches embracing alternate pools or bend crossings, in order that like conditions might be compared and the differences developed might be studied. As the crossings are frequently not coincident i two surveys a sufficient length has been taken to cover the crossings at both ep In some cases this requires that part of the pool in one or both surveys be inc in the stretch considered as a crossing. Individual results might therefore be fied by a different arrangement of stretches. The general result, however, i affected.

The results for each of the individual sections, 1,131 in number, have been dec and tabulated so as to show for each survey the number of section, elevati water surface when sounded, the width, area, mean depth and maximum dep low water, medium, and bank-full stages. These elements are also shown graphi on plates 19, 20, 21, and 22.

The means of the elements by stretches are also tabulated (see Table No. 8) an also shown graphically, as follows: Vicksburg to Natchez, Reach 1, on plat Natchez to Red River, Reach 2, on plate 24; Red River to Scot Bluff, Reach plate 25, and Scot Bluff to Donaldsonville, Reach 4, on plate 26. The sketches s ing the relative changes in mean sections, in bends and on crossings, are show plates 27, 28, 29, 30, and 31.

Table No. 9 gives the averages of cross sections by reaches, showing the bend crossings separately, and also showing the results as a whole with bends and c ings combined.

Table No. 10 gives the elements of controlling sections on crossings. In this the controlling section on any crossing is that section having the least tha depth.

Table No. 11 is a tabulated summary of the mean changes in cross-section elem

Table No. 12 shows for each survey the length of river where the cross-se elements of one survey exceed those of the other.

These tables and diagrams show fully the nature and magnitude of the ch that have occurred and do not need any minute explanation.

The general conclusions derived from these comparisons are briefly as follow

1. The channel capacity of the bed of the river between high-water bank greater in 1895–96 than in 1882–83, due mainly to changes above the medium line.

2. The thalweg depths on the crossings were greater in 1882–83 than in 1895- all of the reaches.

3. The thalweg depth in the bends was greatest in 1895–96 in the first reach greatest in 1882–83 in reaches 2, 3, and 4.

4. As a whole, the combined pools and crossings, Vicksburg to Donaldson the average of 1,131 sections, shows both mean and thalweg depths greate 1882–83.

5. Considered by length of river the width was greater in 1895–96 for 58.6 per of the length at low water, 64.5 per cent at medium stage, and 68.2 per cent at b full stage.

The area was greater in 1895–96 for 45.7 per cent of the total length at low w 46.9 per cent at medium stage, and 51.5 per cent at bank-full stage.

The mean depth was greater in 1895–96 for 41.1 per cent of the total length a water, 42.7 per cent at medium stage, and 35.8 per cent at bank-full stage. The imum depth was greatest in 1895–96 for 39.5 per cent of the total length.

(For further details see Table No. 12.)

TABLE No. 8.—*Comparisons of cross-section elements, Vicksburg, Miss., to Donaldsonville, La., surveys of 1882–83 and 1895–96.*

[The stretches are derived by separating the river into lengths covering the alternate pools and crossings.]

AT LOW WATER.

No. of stretch.	Distance from Cairo.	Average stage when sounded (above Memphis datum).		Average width of cross sections.		Average area of cross sections.		Average mean depth at low water.		Average maximum depth at low water.	
		1882–83.	1895–96.	1882–83.	1895–96.	1882–83.	1895–96.	1882–83.	1895–96.	1882–83.	1895–96.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
	598.0										
	601.3	64.2	48.2	1,792	1,754	66,192	57,653	38.1	34.1	68.2	62.2
	603.0	62.5	46.6	1,676	2,378	31,264	31,492	21.9	14.1	41.4	26.2
	605.5	61.5	46.2	1,748	1,247	34,910	36,370	23.2	29.2	43.1	52.6
	608.3	58.9	45.9	1,927	1,780	34,350	45,800	17.9	26.9	30.1	38.8
	611.0	57.9	45.2	1,739	1,781	36,617	46,346	21.2	26.2	30.2	40.1
	613.4	56.7	44.3	2,220	2,570	34,816	34,480	16.2	14.5	27.0	24.6
	616.6	56.6	41.5	1,741	1,845	34,680	42,616	20.2	24.2	28.6	39.6
	619.0	57.1	39.5	1,652	2,501	30,712	27,692	19.6	11.3	31.9	21.6
	620.5	57.2	36.4	1,284	1,391	28,440	32,726	21.9	23.5	27.8	37.8
	622.5	57.5	35.9	2,091	1,661	39,408	37,274	20.2	20.7	28.7	36.0
	624.5	57.5	35.5	1,306	1,469	28,950	35,672	22.5	24.4	32.4	46.0
	625.8	57.8	35.2	1,852	1,604	50,576	40,208	25.5	25.5	41.4	35.2
	629.0	57.2	35.0	1,784	1,677	49,889	44,917	28.1	27.4	42.4	50.0
	630.6	56.1	34.6	2,046	2,061	30,152	41,885	14.7	21.7	24.9	44.2
	632.7	54.5	34.5	1,346	1,722	39,333	57,913	30.7	34.5	44.4	55.0
	634.5	54.2	34.5	1,507	2,522	38,198	40,320	26.7	16.2	38.7	30.4
	637.5	53.8	34.2	1,559	1,980	51,618	55,029	33.9	30.3	45.5	51.6
	639.0	53.0	34.1	1,966	2,454	27,120	57,067	17.6	26.5	35.8	40.1
	641.2	51.7	34.0	1,607	1,705	47,709	55,085	33.8	32.9	47.3	58.1
	643.8	50.4	33.7	2,084	2,483	26,776	41,033	12.5	17.9	32.3	29.6
	646.3	48.9	32.8	2,492	1,781	26,227	50,007	10.8	30.6	22.2	44.8
	648.0	48.6	32.3	2,770	2,978	38,313	45,469	15.3	15.4	20.5	28.6
	650.0	49.2	32.9	1,801	1,606	67,218	57,649	38.5	39.0	65.0	63.9
	652.0	49.9	33.0	2,037	1,920	76,676	63,168	37.8	33.2	57.5	55.9
	655.0	49.9	33.3	1,622	1,702	70,817	77,604	47.6	47.8	67.8	75.4
	657.0	51.2	33.6	2,005	2,509	38,252	44,828	20.5	18.8	40.6	34.0
	659.2	52.0	33.1	1,889	1,966	34,287	46,961	19.0	24.7	33.2	49.7
	661.2	52.2	33.9	2,824	2,517	35,083	52,797	12.9	21.1	27.5	35.8
	664.5	51.0	33.1	2,028	2,496	41,188	52,882	23.2	21.3	45.8	37.3
	{679.7 681.8}	52.3	32.5	2,998	2,378	61,015	62,998	22.3	27.8	58.1	50.8
31	684.4	55.4	32.3	2,546	1,865	72,668	64,185	28.9	36.7	61.2	67.1
32	686.0	58.4	32.2	3,081	2,613	60,517	61,734	19.7	22.9	38.7	44.5
33	690.0	59.3	31.2	2,105	1,978	70,063	58,814	34.1	30.0	69.2	55.3
34	691.5	59.7	30.2	2,776	3,011	65,914	58,611	23.7	17.9	51.3	35.0
35	695.2	59.6	28.8	1,920	1,894	72,441	56,062	39.1	30.4	71.6	52.0
36	698.4	61.7	27.8	1,918	2,747	83,735	53,676	43.9	19.6	81.0	35.9
37	701.0	58.4	27.2	1,805	1,737	86,464	70,126	48.0	40.5	87.8	74.5
38	705.0	33.3	26.8	2,551	2,792	61,108	68,264	25.0	26.0	40.8	39.0
39	707.0	32.9	25.8	2,744	3,339	39,400	51,224	14.1	10.9	27.2	37.2
40	709.8	33.2	26.9	2,594	2,996	43,894	38,499	16.9	13.0	30.7	35.3
41	713.7	32.8	29.9	2,304	2,992	35,889	38,101	16.7	13.2	29.3	26.2
42	716.0	32.7	33.7	1,933	2,572	80,704	49,708	41.6	19.7	65.7	37.6
43	719.4	32.4	42.2	1,723	1,845	67,965	57,702	41.0	32.7	66.9	61.5
44	721.0	33.2	42.9	2,198	2,834	42,119	50,385	19.7	17.8	38.0	25.9
	723.0	32.6	42.9	1,648	2,483	34,793	50,108	21.4	21.5	42.8	45.4
	725.4	31.6	43.9	2,525	2,740	42,197	60,540	17.4	23.0	28.2	32.0
	727.4	30.8	43.7	1,570	2,202	60,664	60,433	38.0	29.4	73.9	63.3
	728.9	30.0	43.5	1,927	1,898	64,670	68,468	33.7	37.4	66.0	63.6
	732.9	29.7	43.4	2,003	2,079	60,345	62,806	30.9	31.5	55.7	50.5
	736.5	28.9	42.9	2,113	1,881	60,035	61,977	29.0	33.6	55.2	64.3
	738.0	28.2	41.7	2,840	2,829	54,044	55,037	19.1	19.6	34.6	46.6
	742.0	27.2	37.5	1,509	1,582	55,676	48,088	35.7	29.3	70.9	55.7
	743.4	26.0	32.8	1,995	2,212	58,562	57,845	29.9	17.1	56.3	34.9
	745.9	25.4	30.8	1,850	1,828	59,500	54,215	33.1	30.3	65.9	54.2
	747.2	25.2	24.0	2,104	1,831	74,203	64,569	35.1	35.0	59.0	58.8
	750.2	25.1	21.3	1,854	1,701	68,760	66,338	41.4	36.2	75.6	65.8
	752.4	34.6	18.7	2,378	2,261	52,363	65,523	22.8	30.0	45.7	45.3
	754.2	32.9	17.9	1,925	2,581	84,019	55,851	43.9	21.8	78.4	37.4
	755.8	26.3	14.8	2,087	2,102	133,531	72,899	64.2	35.4	107.7	73.6
	757.4	31.2	13.7	1,712	1,609	78,722	77,017	46.0	48.1	97.3	85.8
	759.0	31.9	13.9	2,884	2,483	64,049	76,033	23.3	33.4	36.9	57.5
	763.8	31.5	13.9	2,276	2,016	69,041	71,790	31.3	38.0	52.8	56.6
	766.0	31.0	13.6	3,299	3,687	75,178	59,136	23.4	16.2	38.6	32.5
	771.3	30.4	12.9	2,490	2,110	76,527	65,323	35.2	32.2	65.8	58.2
	772.5	29.7	12.7	2,324	2,157	80,646	71,297	33.7	33.6	57.3	57.8
	777.5	30.2	12.5	2,013	1,864	83,030	69,631	43.1	39.4	77.7	58.6
	779.4	30.8	12.1	3,103	3,236	66,231	67,266	21.5	21.1	35.1	33.6
	783.8	35.4	11.7	2,412	1,920	89,398	71,700	39.7	39.3	74.7	60.5

TABLE No. 8.—*Comparisons of cross-section elements, Vicksburg, Miss., etc.*—Co

AT LOW WATER—Continued.

No. of stretch.	Distance from Cairo.	Average stage when sounded (above Memphis datum).		Average width of cross sections.		Average area of cross sections.		Average mean depth at low water.		Avera mum low
		1882–83.	1895–96.	1882–83.	1895–96.	1882–83.	1895–96.	1882–83.	1895–96.	1882–8
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*
69	784.8	37.3	11.8	2,884	2,356	97,897	81,671	35.3	35.1	55.
70	790.2	37.4	11.3	2,085	1.880	90,578	75,523	45.9	41.2	100.
71	792.0	37.5	10.9	1,965	2,176	71,390	80,377	48.9	37.7	77.
72	793.9	37.6	10.5	2,055	2,315	86,942	70,387	43.0	33.6	89.
73	795.1	37.6	10.6	1,974	2,105	105,208	85,472	53.3	40.5	94.
74	797.7	38.0	10.6	1,966	1,916	98,658	83,378	50.2	44.6	93.
75	799.9	36.0	10.4	3,133	3,130	75,012	79,888	26.6	26.3	46.
76	804.7	24.8	9.8	2,090	2,154	77,851	75,942	38.3	37.3	70.
77	806.6	24.6	9.3	2,412	2,752	79,368	82,956	33.3	30.4	53.
78	811.4	24.1	8.9	2,054	2.027	101,423	106,818	49.3	53.9	90.
79	812.8	23.9	8.9	2.720	2,970	80,540	77,880	31.5	27.6	49.
80	816.9	23.5	8.3	2,462	2,620	69,772	79,670	28.7	30.3	65.
81	818.6	22.7	8.4	2,790	2,932	95,024	84,804	28.2	29.4	57.
82	821.3	22.6	8.4	1,990	1,877	91,730	89,762	46.3	48.8	87.
83	825.1	22.7	8.5	1,985	2,011	106,563	106,695	54.9	53.3	101.
84	827.2	23.5	8.4	2,100	2,220	87,971	91,426	41.9	41.9	72.
85	830.5	23.1	8.2	2,022	2,185	126,520	126,620	61.6	58.8	101.
86	835.0	27.7	8.8	2,244	2,466	97,752	94,138	44.0	38.8	66.
87	839.6	29.9	9.1	2,653	2,732	93,011	93,094	36.0	35.0	73.
88	842.9	30.4	9.1	2,314	2,437	102,382	102,196	47.7	46.3	101.
89	846.5	31.5	8.4	2,329	2,540	106,785	102,250	46.0	40.4	65.
90	849.8	32.5	8.5	2,385	2,447	115,032	108,175	49.5	45.7	103.
91	851.5	33.0	8.1	2,756	2,816	107.088	105,600	40.5	39.7	69.
92	857.5	33.1	8.3	2,225	2,343	105.429	103,691	49.4	46.5	102.
93	861.3	32.7	8.1	2,833	2,928	108,440	104,484	40.8	37.2	73.
94	864.0	33.0	8.1	2,251	2,267	135,231	119.804	62.4	55.2	116.
95	866.0	32.8	8.2	2,624	2,742	117,432	110,248	45.8	41.2	86.
96	870.6	32.8	8.4	2,564	2,487	122,902	110,303	53.4	47.6	107.
97	872.8	32.2	8.5	2,533	2,650	113,470	111,300	45.5	42.6	68.
98	877.0	32.1	8.6	2,519	2,493	116,055	111,120	50.0	47.1	94.
99	879.6	31.8	9.3	2,640	2,640	112,069	115,297	42.4	43.9	63.
100	882.3	31.7	9.2	2.277	2,360	150,310	132,086	69.4	58.1	116.
101	885.3	31.2	8.7	2,362	2,313	140,593	139,833	61.3	61.9	111.

AT MEDIUM STAGE.

No. of stretch.	Distance from Cairo.	Average stage when sounded (above Memphis datum).		Average width of cross sections.		Average area of cross sections.		Avera dep mediu
		1882–83.	1895–96.	1882–83.	1895–96.	1882–83.	1895–96.	1882–83
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*
	598.0							
1	601.3	64.2	48.2	3,308	2,917	147,740	137,806	48.
2	603.0	62.5	46.6	5,010	5,756	143.972	163,824	28.
3	605.5	61.5	46.2	5,752	4,977	160,570	151,433	27.
4	608.3	58.9	45.9	3,573	4,730	125,170	140,603	35.
5	611.0	57.9	45.2	3,693	3,094	126,743	127,086	34.
6	613.4	56.7	44.3	3,822	5,148	135,832	152,338	36.
7	616.6	56.6	41.5	3,755	3,664	128,760	137,351	35.
8	619.0	57.1	39.5	3,777	5,502	126,407	162,880	29.
9	620.5	57.2	36.4	3,726	3,443	121,757	121,368	32.
10	622.5	57.5	35.9	3,757	4,344	145,511	147,283	38.
11	624.5	57.5	35.3	5,802	7,809	122,635	163,820	21.
12	625.8	57.3	35.2	3,926	5,248	154,364	150,088	42.
13	629.0	57.2	35.0	3,324	3,778	143,750	143,934	44.
14	630.6	56.1	34.6	3,767	3,684	136,898	149,934	36.
15	632.7	54.5	34.5	3,104	3,222	120,429	143,491	40.
16	634.5	54.2	34.5	3,717	3,490	123.408	142.382	34.
17	637.5	53.8	34.2	4,004	3,657	143,269	149,049	36.
18	639.0	53.0	34.1	3,924	4,574	141,025	158,657	35.
19	641.2	51.7	34.0	3,412	3,626	124,880	144,298	37.
20	643.8	50.4	33.7	5,431	5,006	158,440	164,700	29.
21	646.3	48.9	32.3	4,294	3,533	137,647	129.080	32.
22	648.0	48.6	32.3	3,754	3,432	143,071	153,580	38.
23	650.0	49.2	32.9	3,084	3,725	146,845	143,304	48.
24	652.0	49.9	33.0	3,473	4,294	161,550	160,984	47.
25	655.0	49.9	33.3	2,701	2,783	137.386	149,283	52.
26	657.0	51.2	33.6	6,840	5,935	168,202	172,694	25.
27	659.3	53.0	33.1	6,577	7,356	154,947	185,721	24.

TABLE No. 8.—*Comparisons of cross-section elements, Vicksburg, Miss., etc.*—Continue

AT MEDIUM STAGE—Continued.

Distance from Cairo.	Average stage when sounded (above Memphis datum). 1882-83.	Average stage when sounded (above Memphis datum). 1895-96.	Average width of cross sections. 1882-83.	Average width of cross sections. 1895-96.	Average area of cross sections. 1882-83.	Average area of cross sections. 1895-96.	Average mean depth at medium stage. 1882-83.	Average mean depth at medium stage. 1895-9
Miles.	Feet.	Feet.	Feet.	Feet.	Sq. feet.	Sq. feet.	Feet.	Feet.
[illegible]31.2	52.2	33.9	4,031	4,448	138,123	155,640	34.3	35.
[illegible]34.5	51.0	33.1	5,366	4,873	140,049	149,332	26.5	31.
[illegible]79.7 [illegible]82.0	53.3	32.5	4,858	3,964	156,866	152,392	34.2	39.
[illegible]84.4	55.4	32.8	3,842	3,522	152,505	128,257	40.0	37.
[illegible]86.0	58.4	32.2	3,490	3,356	139,923	134,220	40.2	39.
690.0	59.3	31.2	3,789	4,387	142,511	133,628	39.4	31.
691.5	59.7	30.2	3,760	4,569	148,766	146,594	39.6	32.
695.2	59.6	28.8	3,170	4,267	134,862	130,642	43.2	32.
698.4	61.7	27.8	3,303	3,895	151,248	136,215	46.4	36.
701.0	58.4	27.2	2,535	2,712	141,512	126,304	57.3	48.
705.0	33.6	26.8	2,920	3,035	131,486	140,824	46.4	47.
707.0	32.9	25.8	6,252	5,768	153,460	176,207	24.8	30.
709.8	33.2	26.9	4,032	5,231	140,320	156,757	35.8	30.
713.7	32.8	29.9	5,530	5,624	149,157	162,704	27.4	30.
716.0	32.7	33.7	2,692	4,442	146,592	151,029	56.1	34.
719.4	32.4	42.2	3,146	3,469	134,449	127,792	46.4	40.
721.0	33.2	42.9	5,962	5,175	146,399	159,360	25.2	31.
723.0	32.6	42.9	5,528	5,548	133,114	154,740	24.7	28.
725.4	31.6	43.9	4,850	4,228	151,647	156,182	31.1	37.
727.4	30.3	43.7	3,423	3,742	127,352	144,168	43.2	39.
728.9	30.0	43.5	3,077	3,100	140,723	140,660	47.6	45.
732.9	29.7	43.4	3,907	2,974	144,627	133,338	37.6	45.
736.5	28.9	42.9	2,960	2,810	136,004	133,154	46.2	47.
738.0	28.2	41.7	3,426	3,491	150,366	152,500	43.8	44.
742.0	27.2	37.5	3,379	4,085	163,954	131,176	42.9	33.
743.4	26.0	32.8	3,901	3,812	142,090	145,412	37.8	38.
745.9	25.4	30.3	4,155	3,869	144,620	134,390	36.1	34.
747.2	25.2	24.0	3,309	3,189	153,426	134,039	47.4	42.
750.2	25.1	21.3	3,540	3,290	143,990	141,322	42.1	43.
752.4	34.6	18.7	3,846	3,607	150,044	153,512	39.2	42.
754.2	32.9	17.9	3,035	3,218	159,966	147,001	52.8	45.
755.8	26.3	14.8	3,183	3,230	206,938	146,743	68.6	47.
757.4	31.2	13.7	2,843	2,742	142,540	137,572	50.7	50.
759.0	31.9	13.9	3,406	3,080	151,277	152,313	44.6	50.
763.8	31.5	13.9	4,303	4,324	163,744	154,614	38.9	36.
766.0	31.0	13.6	4,003	4,140	173,594	163,410	43.5	39.
771.3	30.4	12.9	3,395	3,518	158,817	142,806	48.1	41.
772.5	29.7	12.7	2,943	2,900	152,129	141,451	51.8	47.
777.5	30.2	12.5	2,942	2,981	150,767	133,507	52.9	46.
779.4	30.8	12.1	4,472	4,302	167,253	165,770	37.6	38.
783.8	35.4	11.7	3,313	3,353	164,183	142,883	53.1	45.
748.8	37.3	11.8	3,407	3,010	177,326	151,489	51.9	50.
790.2	37.4	11.3	2,970	2,910	156,523	137,228	54.0	47.
792.0	37.5	10.9	2,551	2,685	156,535	142,025	61.9	53.
792.9	37.6	10.5	3,642	3,792	166,213	155,969	46.1	41.
795.1	37.6	10.6	2,568	2,662	164,588	148,160	64.3	55.
797.7	38.0	10.6	2,943	2,821	161,325	145,333	55.0	51.
799.9	36.0	10.4	3,816	3,944	163,854	170,706	44.0	44.
804.7	24.8	9.8	2,826	2,913	143,543	145,328	53.8	52.
806.6	24.6	9.3	2,962	3,106	150,736	159,372	51.4	52.
811.4	24.1	8.9	2,965	3,177	167,289	177,895	57.1	58.
812.8	23.9	8.9	3,102	3,190	153,830	154,780	51.1	49.
816.9	23.5	8.3	4,595	4,294	158,364	163,591	35.4	40.
818.8	22.7	8.4	3,560	3,922	154,632	168,252	43.5	45.
821.3	22.6	8.4	3,039	3,220	148,511	146,307	49.6	41.
825.1	22.7	8.5	2,646	2,710	154,517	161,947	61.6	59.
827.2	23.5	8.4	2,493	2,493	136,900	136,209	56.4	56.
830.5	23.1	8.2	2,505	2,589	174,905	180,333	69.6	67.
835.0	27.7	8.8	2,541	2,703	144,222	144,584	57.7	53.
839.6	29.9	9.1	3,107	3,349	146,683	149,428	47.7	45.
842.9	30.4	9.1	2,747	2,952	150,491	152,913	56.3	54.
846.5	31.5	8.4	2,517	2,749	151,315	150,680	60.2	54.
849.8	32.5	8.5	2,603	2,915	160,748	157,002	63.5	55.
851.5	33.1	8.1	2,922	3,092	158,612	159,952	56.0	52
857.5	33.1	8.8	2,463	2,594	146,299	147,269	61.0	58
861.3	32.7	8.1	2,959	3,092	157,432	155,564	55.0	51
864.0	33.0	8.1	2,462	2,512	174,809	160,087	72.4	65
866.0	32.8	8.2	2,782	2,928	161,456	166,868	59.1	54
870.6	32.8	8.4	2,792	2,945	165,802	154,340	63.8	55
872.8	32.2	8.5	2,710	2,858	154,030	154,573	57.7	55
877.0	32.1	8.6	2,733	2,931	155,607	152,435	60.9	54
879.6	31.8	9.3	2,763	2,889	148,714	152,726	53.9	53
882.3	31.7	9.2	2,647	2,660	186,423	169,306	74.8	64
885.3	31.2	8.7	2,505	2,582	175,680	175,157	71.5	68

TABLE NO. 8.—*Comparisons of cross-section elements, Vicksburg, Miss., etc.*—Con

AT BANK-FULL STAGE.

No. of stretch.	Distance from Cairo.	Average stage when sounded (above Memphis datum).		Average width of cross sections.		Average area of cross sections.		Averag dep mediu
		1882-83.	1895-96.	1882-83.	1895-96.	1882-83.	1895-96.	1882-83.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*
	598.0							
1	601.8	64.2	48.2	4,179	3,769	199,303	184,555	52.6
2	603.0	62.5	46.6	8,054	6,758	247,088	241,496	30.6
3	605.5	61.5	46.2	7,258	6,723	254,030	235,843	35.3
4	608.3	58.9	45.9	4,418	5,500	192,187	225,473	44.5
5	611.0	57.9	45.2	4,186	5,570	188,480	194,206	45.2
6	613.4	56.7	44.3	5,828	5,985	203,944	230,376	35.8
7	616.6	56.6	41.5	5,335	4,776	193,156	195,865	37.5
8	619.0	57.1	39.5	4,929	7,880	195,080	265,077	40.6
9	620.5	57.2	36.4	5,244	5,118	182,628	178,911	35.0
10	622.5	57.5	35.9	4,169	4,430	206,554	210,137	49.3
11	624.5	57.5	35.3	6,699	8,406	224,688	296,862	33.6
12	625.8	57.3	35.2	5,422	6,878	229,092	241,616	42.9
13	629.0	57.2	35.0	4,281	4,504	194,614	197,590	43.6
14	630.6	56.1	34.6	4,240	4,785	195,000	213,306	46.7
15	632.7	54.5	34.5	3,991	5,071	158,249	187,742	40.2
16	634.5	54.2	34.5	4,591	4,592	169,442	184,147	39.3
17	637.5	53.8	34.2	5,408	5,283	191,069	195,476	36.5
18	639.0	53.0	34.1	4,036	5,880	190,012	228,902	47.2
19	641.2	51.7	34.0	3,843	5,493	175,200	208,582	46.1
20	643.8	50.4	33.7	5,911	6,182	238,793	243,893	41.1
21	646.3	48.9	32.5	4,579	4,595	205,615	195,887	45.0
22	648.0	48.6	32.3	4,257	3,616	206,978	205,420	47.9
23	650.0	49.2	32.9	3,691	4,898	193,853	205,031	52.4
24	652.0	49.9	33.0	4,164	5,811	220,682	234,310	56.2
25	655.0	49.9	33.3	3,173	3,569	179,675	196,752	57.5
26	657.0	51.2	33.6	7,064	8,340	177,270	184,302	41.0
27	659.3	53.0	33.1	8,040	11,417	276,478	346,630	35.8
28	661.2	52.2	33.9	4,389	4,576	201,357	223,756	46.0
29	664.5	51.0	33.1	5,932	5,530	220,563	220,980	37.4
30	679.7 682.0	52.8	32.5	5,159	5,308	223,636	207,635	44.3
31	684.4	55.4	32.8	4,170	5,087	212,912	199,578	51.3
32	686.0	58.4	32.2	3,623	3,908	194,520	191,437	52.4
33	690.0	59.3	31.2	5,361	5,198	207,501	200,207	40.3
34	691.5	59.7	30.2	5,527	6,711	220,880	233,286	41.0
35	695.2	59.6	28.8	3,988	6,061	188,955	198,831	46.2
36	698.4	61.7	27.8	4,062	4,349	211,223	200,435	52.8
37	701.0	58.4	27.2	3,229	3,421	191,348	180,584	62.5
38	705.0	33.3	26.8	3,248	3,180	187,297	195,847	58.6
39	707.0	32.9	25.8	6,718	7,494	278,993	309,027	40.8
40	709.8	33.2	26.9	4,372	5,348	213,365	251,215	49.1
41	713.7	32.8	29.9	5,995	6,178	234,302	253,749	40.4
42	716.0	32.7	33.7	3,096	5,126	189,128	221,392	63.7
43	719.4	32.4	42.2	4,416	4,420	192,322	187,355	46.6
44	721.0	33.2	42.9	7,700	7,991	253,704	258,870	32.8
45	723.0	32.6	42.9	7,108	10,836	232,758	278,405	34.0
46	725.4	31.6	43.9	7,701	7,817	234,025	227,989	30.6
47	727.4	30.3	43.7	4,329	4,869	182,758	205,726	48.3
48	728.9	30.0	43.5	3,422	3,968	193,013	199,040	57.2
49	732.9	29.7	43.4	4,138	4,528	211,922	199,895	52.0
50	736.5	28.9	42.9	3,248	3,475	187,006	184,877	57.6
51	738.0	28.2	41.7	3,617	3,687	204,723	209,274	57.5
52	742.0	27.0	37.5	3,785	4,574	185,020	193,099	50.5
53	743.4	26.0	32.8	4,859	4,494	209,640	211,735	44.1
54	745.9	25.4	30.8	4,606	4,838	212,305	203,482	45.1
55	747.2	25.2	24.0	3,846	3,730	211,591	191,384	55.8
56	750.2	25.1	21.8	4,592	5,125	208,333	206,637	46.3
57	752.4	34.6	18.7	4,013	4,230	213,229	218,369	53.2
58	754.2	32.9	17.9	3,413	3,425	205,346	194,677	60.3
59	755.8	26.3	14.8	3,873	4,068	263,000	204,701	69.0
60	757.4	31.2	13.7	3,523	4,836	201,310	211,180	57.4
61	759.0	31.9	13.9	3,499	3,873	216,549	221,375	62.1
62	763.8	31.5	13.9	4,512	4,541	234,076	227,867	52.6
63	766.0	31.0	13.6	4,138	4,277	237,360	232,814	57.7
64	771.3	30.4	12.9	3,560	3,651	207,308	194,670	59.8
65	772.5	29.7	17.7	3,096	3,176	196,551	187,246	63.4
66	777.5	30.2	12.5	3,330	3,828	197,763	180,511	60.9
67	779.4	30.8	12.1	5,980	5,916	236,641	232,790	40.0
68	783.8	35.4	11.7	3,888	3,734	212,700	190,590	59.7
69	784.8	37.3	11.8	3,787	2,801	233,130	201,237	63.9
70	790.2	37.4	11.3	3,501	3,854	196,990	177,756	56.5
71	792.0	37.5	10.9	2,896	2,865	186,386	172,230	65.3
72	793.9	37.6	10.5	3,934	4,175	205,360	198,093	52.8

TABLE No. 8.—*Comparisons of cross-section elements, Vicksburg, Miss., etc.*—Continued.

AT BANK-FULL STAGE—Continued.

No. of stretch.	Distance from Cairo.	Average stage when sounded (above Memphis datum).		Average width of cross sections.		Average area of cross sections.		Average mean depth at medium stage.	
		1882–83.	1895–96.	1882–83.	1895–96.	1882–83.	1895–96.	1882–83.	1895–96.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*
73	795.1	37.6	10.6	2,860	2,868	198,420	182,992	69.9	64.1
74	797.7	38.0	10.6	3,231	3,180	190,436	174,170	59.2	55.7
75	799.9	36.0	10.4	4,078	4,048	210,516	217,178	53.5	54.8
76	804.7	24.8	9.8	2,923	3,072	182,468	186,325	65.4	63.8
77	806.6	24.6	9.3	3,058	3,202	189,096	199,916	63.5	63.1
78	811.4	24.1	8.3	3,227	3,471	202,511	216,206	63.6	63.1
79	812.8	23.9	8.9	3,167	3,245	190,530	192,650	61.5	60.0
80	816.9	23.5	8.8	5,117	5,296	211,610	217,754	42.8	42.3
81	818.6	22.7	8.4	3,806	3,966	198,042	210,232	52.5	53.6
82	821.3	22.6	8.4	3,290	3,592	184,456	183,888	56.4	51.4
83	825.1	22.7	8.5	3,044	3,107	186,260	189,969	62.3	61.4
84	827.2	23.5	8.4	2,509	2,590	165,474	170,163	64.9	65.7
85	830.5	23.1	8.2	2.742	2,750	202,836	208,907	74.6	74.6
86	835.0	27.7	8.8	2.784	2,829	174,093	175,593	63.7	62.8
87	839.6	29.9	9.1	3,831	3,527	180,856	179,057	55.4	52.7
88	842.9	30.4	9.1	3,217	3,144	186,117	190,340	59.1	62.8
89	846.5	31.5	8.4	2,748	2,878	181,812	183,057	66.6	63.8
90	849.8	32.5	8.5	3,215	3,088	193,152	191,152	61.0	63.2
91	851.5	33.0	8.1	3,194	3,246	193,524	195,552	62.0	61.4
92	857.5	33.1	8.3	2,696	2,728	174,096	176,760	65.5	65.9
93	861.3	32.7	8.1	3,297	3,277	188,128	186,896	58.5	58.0
94	864.0	33.0	8.1	2,852	2,687	200,787	186,553	70.7	71.0
95	866.0	32.8	8.2	2,942	3,036	190,816	190,924	65.2	63.7
96	870.6	32.8	8.4	2,990	3,037	195,302	185,310	68.7	64.0
97	872.8	32.2	8.5	2,823	2,952	170,490	181,403	64.6	62.1
98	877.0	32.1	8.6	3,233	3,170	182,015	180,224	57.5	59.4
99	879.6	31.8	9.3	2,944	2,981	176,800	181,977	60.1	61.1
100	882.3	31.7	9.2	3,217	2,916	213,617	196,187	68.6	68.4
101	885.3	31.2	8.7	2,737	2,739	201,293	200,283	74.1	74.8

TABLE No. 9.—*Averages of cross-section elements by reaches, Vicksburg to Donaldsonville.*

[As the distance between sections and the lengths of stretches vary throughout the whole length of river considered, the averages here given are weighted according to the lengths involved.]

BENDS (166.5 MILES).

Reach.	Average widths.		Average areas.		Average mean depths.		Average maximum depths.	
	1882–83.	1895–96.	1882–83.	1895–96.	1882–83.	1895–96.	1882–83.	1895–96.
Low water:								
Vicksburg to Natchez	1,861	1,777	58,026	58,826	30.2	31.4	51.1	54.6
Natchez to Red River	2,007	2,116	61,534	60,101	32.4	30.5	59.0	53.8
Red River to Scot Bluffs	2,166	2,054	87,592	80,799	44.8	41.0	82.8	74.7
Scot Bluffs to Donaldsonville	2,333	2,379	121,157	111,976	54.8	50.9	105.3	98.0
Medium stage:								
Vicksburg to Natchez	3,878	3,959	139,863	141,628	39.1	39.2	....	....
Natchez to Red River	3,661	3,710	145,295	141,107	41.4	40.2	....	....
Red River to Scot Bluffs	3,187	3,223	156,813	149,575	52.0	48.2	....	....
Scot Bluffs to Donaldsonville	2,609	2,753	163,730	159,099	66.6	59.7	....	....
Bank-full stage:								
Vicksburg to Natchez	4,801	5,472	205,368	212,316	45.1	42.3	....	....
Natchez to Red River	4,210	4,689	205,265	209,584	51.0	47.1	....	....
Red River to Scot Bluffs	3,535	3,599	198,531	191,860	58.6	55.2	....	....
Scot Bluffs to Donaldsonville	2,975	2,921	191,300	188,949	66.0	66.5	....	....

TABLE NO. 9.—*Averages of cross-section elements by reaches, etc.*—Continue

CROSSINGS (105.6 MILES).

Reach.	Average width.		Average areas.		Average mean depth.		Averag mum
	1882–83.	1895–96.	1882–83.	1895–96.	1882–83.	1895–96.	1882–83.
Low water:							
Vicksburg to Natchez.....	2,093	2,345	44,534	46,006	22.3	20.3	37.5
Natchez to Red River......	2,320	2,585	59,612	56,584	27.1	22.7	47.3
Red River to Scot Bluffs...	2,633	2,757	81,582	78,817	33.6	30.3	56.8
Scot Bluffs to Donaldsonville	2,554	2,677	104,989	102,550	42.2	39.2	70.4
Medium stage:							
Vicksburg to Natchez.....	4,178	4,601	145,871	151,824	35.7	34.0	....
Natchez to Red River......	4,234	4,276	152,667	154,056	40.0	38.3	....
Red River to Scot Bluffs...	3,299	3,367	158,380	155,586	50.0	48.2	....
Scot Bluffs to Donaldsonville	2,792	3,045	151,454	151,746	55.5	48.0	....
Bank-full stage:							
Vicksburg to Natchez.....	5,090	5,594	207,496	221,599	43.8	42.3	....
Natchez to Red River......	4,973	5,376	225,166	230,417	49.3	45.3	....
Red River to Scot Bluffs...	3,624	3,595	206,135	201,216	58.9	57.5	....
Scot Bluffs to Donaldsonville	3,006	3,102	182,033	182,829	61.5	60.1	....

BENDS AND CROSSINGS COMBINED (272.1 MILES).

Low water:							
Vicksburg to Natchez.....	1,963	2,025	49,312	50,406	26.7	26.5	45.1
Natchez to Red River......	2,127	2,295	60,800	58,757	30.4	27.6	54.5
Red River to Scot Bluffs...	2,302	2,258	85,849	80,079	40.0	37.9	74.9
Scot Bluffs to Donaldsonville	2,427	2,506	114,256	107,953	49.4	45.9	90.4
Medium stage:							
Vicksburg to Natchez.....	4,009	4,289	142,484	146,076	37.6	36.9	....
Natchez to Red River......	2,880	3,926	148,115	146,053	40.9	39.4	....
Red River to Scot Bluffs...	3,220	3,265	157,267	151,318	51.4	48.2	....
Scot Bluffs to Donaldsonville	2,687	2,877	158,146	154,756	61.8	54.7	....
Bank-full stage:							
Vicksburg to Natchez.....	4,927	5,525	206,295	216,365	44.5	42.3	....
Natchez to Red River......	4,501	4,951	212,866	217,541	50.4	46.4	....
Red River to Scot Bluffs...	3,561	3,598	199,868	194,573	58.7	55.8	....
Scot Bluffs to Donaldsonville	2,988	3,000	187,688	186,336	64.1	63.8	....

TABLE NO. 10.—*Comparison of controlling sections on crossings, surveys of 1882-1895-96.*

[The controlling sections are not coincident on account of the shifting of the bars, hence t two numbers given in column 2. The first one is the controlling section for the survey of and the second is the controlling section for 1895–96. The controlling section of each crossin section which shows the least thalweg depth.]

LOW WATER.

Number of stretch.	Number of section.	Width of cross section.		Area of cross section.		Mean depth at low water.		Maxi depth wa
		1882–83.	1895–96.	1882–83.	1895–96.	1882–83.	1895–96.	1882–83.
Vicksburg to Natchez—		*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*
2	7– 9	2,680	2,830	30,960	28,100	11.6	9.9	+21.1
4	18– 21	1,940	2,450	19,140	49,200	9.8	20.1	22.2
6	33	2,860	3,000	34.200	29,940	12.0	10.0	+17.0
8	47– 50	2,300	2,570	29,840	25,220	13.0	9.8	+19.4
10	62– 63	1,730	2,180	28,760	35,740	16.6	16.4	22.7
12	77– 79	1,200	1,760	36,300	41,340	30.2	23.5	+34.0
14	103– 98	1,330	2,420	16,640	38,900	12.5	16.1	20.3
16	114	1,500	2,830	37,160	39,480	24.7	13.9	+33.6
18	132–137	2,200	2,400	28,580	53,960	12.9	22.4	18.0
20	151–158	2,440	2,820	20,920	29,100	8.6	10.8	+17.3
22	171–175	2,730	3,080	27,960	45,520	10.3	14.8	14.6
24	193–192	1,720	2,000	61,280	58,240	35.6	26.8	+48.3

TABLE NO. 10.—*Comparison of controlling sections on crossings, etc.*—Continued.

LOW WATER—Continued.

Number of stretch.	Number of section.	Width of cross section.		Area of cross section.		Mean depth at low water.		Maximum depth at low water.	
		1882-83.	1895-96.	1882-83.	1895-96.	1882-83.	1895-96.	1882-83.	1895-96.
Vicksburg to Natchez—Cont'd.		*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
26	220-222	3,740	2,960	45,420	47,680	12.1	16.1	22.3	+24.0
28	238-240	3,050	2,920	36,200	50,880	11.9	17.4	18.6	+32.8
29	248-250	3,440	2,730	45,020	53,200	13.1	19.5	20.6	+26.0
32	283-284	3,430	3,330	61,800	64,840	18.0	19.5	25.0	+34.8
34	309-310	3,030	3,500	67,840	58,480	22.4	16.7	+31.2	22.8
36	331-332	2,460	3,040	55,600	53,220	22.6	17.5	+64.0	24.0
Sums		43,780	48,820	683,620	798,640	297.9	300.7	470.2	452.6
Means		2,432	2,712	37,979	44,369	16.5	16.7	26.1	25.1
Natchez to Red River:									
39	382-383	3,430	4,040	42,520	51,840	12.4	12.7	16.0	+21.7
41	408-397	3,460	3,840	34,110	38,490	9.9	10.0	+14.8	13.8
42	415	1,560	3,650	53,640	41,380	34.4	11.3	+46.0	28.2
44	450-449	2,640	3,100	42,250	47,750	16.0	15.4	+25.8	22.7
46	470-478	2,920	3,120	35,030	59,440	12.0	19.2	18.8	+24.8
48	493-491	2,020	2,060	62,140	68,820	30.8	33.4	+56.5	37.0
51	535	2,740	2,540	57,770	52,640	21.0	20.7	26.4	+28.4
53	567	1,800	2,620	39,340	54,920	21.8	20.9	+42.5	23.6
55	586-585	2,080	1,770	79,800	68,280	38.3	38.6	+48.3	48.0
57	611-620	3,180	2,740	57,790	52,980	18.1	19.3	25.0	+27.4
59	633-631	3,090	2,100	127,200	56,310	41.1	26.8	+85.5	57.4
61	654-655	3,140	3,100	56,500	76,840	18.0	24.8	24.0	+35.0
Sums		32,060	34,680	688,090	669,190	273.8	253.1	429.1	367.5
Means		2,672	2,890	57,341	55,766	22.8	21.1	35.8	30.6
Red River to Scot Bluffs:									
63	686-684	3,780	4,120	80,440	58,960	21.3	14.3	+28.4	21.5
65	720	2,120	2,000	81,640	75,960	38.5	37.9	+48.0	45.8
67	757-758	3,210	3,420	68,480	67,080	21.3	19.6	+28.5	24.0
69	790-789	3,150	2,320	91,160	79,800	29.0	34.4	36.5	+41.5
71	825	2,080	2,520	106,000	81,280	50.9	32.2	+64.6	45.0
73	837-838	2,070	2,300	100,440	96,920	48.5	42.1	+67.8	51.0
75	858	3,240	3,600	66,840	79,080	20.6	21.9	33.3	+35.5
77	882	2,350	2,630	78,680	86,240	33.4	32.7	+47.8	43.0
79	900	2,500	2,650	93,120	54,800	37.2	20.6	+44.7	44.4
81	917-918	3,500	2,700	75,600	86,480	21.6	32.0	41.5	41.5
84	944-945	2,050	2,410	81,840	92,400	39.9	38.4	+59.0	53.0
Sums		30,050	30,670	924,240	859,100	362.2	326.1	500.1	446.2
Means		2,732	2,788	84,022	78,100	32.9	29.6	45.5	40.6
Scot Bluffs to Donaldsonville:									
86	964-966	2,360	2,930	105,720	88,260	44.8	30.2	+59.0	51.5
87	983-984	3,120	3,350	103,360	98,280	33.1	29.3	+48.5	46.0
89	1009-1010	2,300	2,770	103,680	101,320	45.1	36.6	+52.5	45.8
91	1025	2,690	2,630	111,040	105,200	41.2	43.8	+50.8	50.0
93	1047-1046	3,970	3,150	111,360	109,600	28.0	34.8	+50.0	47.0
95	1068-1066	2,830	2,370	112,200	111,200	39.6	46.9	+66.2	53.2
97	1086-1085	2,550	2,500	90,220	106,680	35.4	42.7	+51.8	48.0
99	1103	2,560	2,690	110,240	118,520	43.1	44.1	+56.4	50.5
Sums		22,380	22,390	847,820	839,060	310.3	308.4	435.2	392.0
Means		2,797	2,799	105,977	104,882	38.8	38.6	54.4	49.0

MEDIUM STAGE.

Vicksburg to Natchez:									
2	7-9	5,600	4,800	173,760	161,020	31.0	33.5	54.6	52.3
4	18-21	3,540	4,380	122,320	160,600	34.5	36.5	56.4	64.0
6	33	6,500	5,720	139,080	160,800	39.7	28.1	49.9	47.7
8	47-50	3,720	4,820	141,380	156,860	38.0	26.2	54.3	51.3
10	62-60	2,940	3,300	118,260	142,700	40.5	43.2	61.6	65.3
12	77-79	3,700	4,180	108,520	142,300	29.3	34.0	72.3	68.4
14	103-98	3,760	4,180	107,280	169,140	29.3	40.5	57.4	60.4
16	114	4,320	3,800	130,900	159,860	30.3	42.1	70.3	55.7

TABLE NO. 10.—*Comparison of controlling sections on crossings, etc.*—Conti

MEDIUM STAGE—Continued.

Number of stretch.	Number of section.	Width of cross section.		Area of cross section.		Mean depth at low water.		Ma dept w
		1882-83.	1895-96.	1882-83.	1895-96.	1882-83.	1895-96.	1882-8
Vicksburg to Natchez—Cont'd.		*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*
18	132- 137	4,340	4,830	160,780	164,120	37.0	34.0	53.
20	151- 158	4,230	4,640	157,000	175,140	37.1	37.7	51.
22	171- 175	4,150	3,540	147,000	158,640	35.4	44.7	49.
24	193- 192	3,030	3,140	134,300	136,480	44.3	43.4	80.
26	220- 222	4,060	6,260	164,800	177,400	40.6	28.3	52.
28	238- 240	3,680	4,040	136,760	157,160	37.2	38.9	48.
29	248- 250	10,230	5,830	237,700	140,960	23.2	24.2	50.
32	283- 284	3,680	3,420	146,720	142,640	39.9	41.7	49.
34	309- 310	3,550	4,420	149,720	158,360	42.2	35.9	51.
36	331- 332	3,860	3,940	138,880	141,860	36.0	36.0	89.
Sums		75,890	79,240	2,615,160	2,806,040	645.5	648.9	1,053.
Means		4,216	4,402	145,287	155,891	35.8	36.0	58.
Natchez to Red River:								
39	382- 383	5,960	6,120	162,920	192,580	27.3	31.4	41.
41	408- 397	7,970	4,440	189,620	160,220	23.8	36.1	43.
42	415	3,720	4,770	121,000	160,260	32.5	33.6	74.
44	450- 449	7,650	5,960	161,490	164,680	21.1	27.6	55.
46	470- 478	4,640	4,130	147,500	159,810	31.8	38.7	48.
48	493- 491	3,830	2,820	149,920	140,760	39.1	48.9	86.
51	535	3,030	3,120	145,160	137,920	47.9	44.2	56.
53	567	4,650	4,600	181,320	157,160	28.2	34.2	73.
55	586- 585	4,750	3,330	165,000	135,280	34.7	40.6	78.
57	611- 620	3,700	3,990	161,410	166,280	43.6	41.6	54.
59	633- 631	4,600	2,820	225,160	131,640	48.9	46.6	113.
61	654- 655	3,470	3,600	147,180	168,360	42.4	46.7	50.
Sums		57,970	49,700	1,907,710	1,874,950	421.8	470.2	776.
Means		4,831	4,142	158,967	156,080	35.1	39.2	63.
Red River to Scot Bluffs:								
63	686- 684	3,960	4,470	182,400	171,220	46.0	38.3	54.
65	720	2,820	2,800	147,840	142,680	52.4	50.9	74.
67	757- 758	4,180	4,270	167,360	167,360	40.0	39.2	54.
69	790- 789	3,700	3,020	177,480	146,240	47.9	48.4	61.
71	825	2,540	2,750	167,280	152,000	65.8	55.2	90.
73	837- 838	2,470	2,560	158,600	159,320	64.2	62.2	92.
75	858	4,360	4,570	168,760	182,160	38.7	39.8	58.
77	882	2,660	2,820	143,160	155,240	53.8	55.0	72.
79	900	2,760	2,960	160,480	126,360	58.2	42.6	60.
81	917- 918	4,020	4,000	169,280	179,360	41.8	44.8	65.
84	944- 945	2,480	2,610	130,800	145,200	32.7	55.6	80.
Sums		35,950	36,830	1,773,440	1,727,140	541.5	532.0	764.
Means		3,268	3,348	161,222	157,013	49.2	48.4	69.
Scot Bluffs to Donaldsonville:								
86	964- 966	2,550	3,150	153,880	147,340	60.3	46.7	79.
87	983- 984	3,350	3,680	164,120	161,680	49.0	43.9	67.
89	1009-1010	2,690	2,970	146,280	152,040	54.4	51.2	70.
91	1025	2,860	2,830	161,400	154,720	56.4	54.7	69.
93	1047-1046	3,970	3,150	176,640	162,520	44.5	51.6	67.
95	1068-1066	2,980	2,550	158,560	152,300	53.2	59.7	82.
97	1086-1085	2,940	2,770	128,700	147,840	43.8	53.4	87.
99	1103	2,670	2,840	145,640	155,840	54.5	54.9	70.
Sums		24,010	23,940	1,235,220	1,234,280	416.1	416.1	573.
Means		3,001	2,993	154,403	154,285	52.0	52.0	71.

TABLE No. 10.—*Comparison of controlling sections on crossings, etc.*—Continued.

BANK-FULL STAGE.

Number of stretch.	Number of section.	Width of cross section.		Area of cross section.		Mean depth at low water.		Maximum depth at low water.	
		1882-83.	1895-96.	1882-83.	1895-96.	1882-83.	1895-96.	1882-83.	1895-96.
Vicksburg to Natchez:		*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
2	7- 9	7,570	8,690	270,540	232,820	35.8	26.8	68.8	67.8
4	18- 21	5,710	5,130	199,060	238,360	34.9	46.4	71.9	80.6
6	33	4,000	5,930	191,140	244,560	47.8	41.3	64.3	62.2
8	47- 50	3,900	7,130	202,980	233,240	52.0	32.7	70.1	65.0
10	62- 63	3,480	3,400	160,800	193,960	42.6	57.0	74.6	80.7
12	77- 79	7,060	5,700	214,560	230,760	30.4	40.5	88.6	85.3
14	103- 98	4,640	4,600	172,280	242,960	37.1	50.8	72.4	76.3
16	114	4,980	4,660	175,860	197,740	35.8	48.7	80.0	65.4
18	132- 137	4,440	5,440	212,780	226,280	47.5	39.8	68.3	75.3
20	151- 158	4,560	6,940	214,200	260,780	47.0	37.6	64.8	66.6
22	171- 175	4,400	3,650	200,820	205,200	45.6	56.2	62.2	69.3
24	193- 192	3,800	5,660	167,660	211,000	49.4	37.8	95.2	90.3
26	220- 222	4,160	6,360	228,720	279,680	55.0	44.0	68.2	70.8
28	238- 240	4,160	4,280	196,060	215,440	47.1	49.3	63.5	77.8
29	248- 250	10,770	5,530	396,400	194,560	36.7	35.2	65.3	67.6
32	283- 284	3,830	3,940	205,420	202,640	53.7	51.5	65.0	74.0
34	309- 310	6,040	5,360	225,120	220,900	37.3	41.0	70.8	60.0
36	331- 332	4,130	4,100	188,840	192,360	45.7	47.0	102.3	62.4
Sums		91,630	95,960	3,842,180	4,023,240	780.9	782.6	1,313.8	1,297.4
Means		5,090	5,328	213,454	223,513	43.4	43.5	73.0	72.1
Natchez to Red River:									
39	382- 383	6,320	6,180	271,960	304,540	48.0	49.8	60.0	65.8
41	408- 397	8,830	4,540	303,620	233,480	34.4	51.4	57.2	58.7
42	415	4,430	5,040	173,040	230,460	40.2	45.7	89.0	71.2
44	450- 449	8,360	8,070	287,490	281,580	34.4	34.9	70.3	67.0
46	470- 478	7,660	7,260	231,300	228,210	30.2	31.4	61.4	68.8
48	493- 491	3,950	4,060	213,400	195,080	54.0	48.0	102.7	82.6
51	535	3,160	3,180	193,920	187,800	61.4	59.1	72.5	74.5
53	567	5,550	4,700	207,020	229,400	37.5	48.8	88.5	69.6
55	586- 585	5,100	3,300	243,380	186,880	47.7	56.6	94.0	93.4
57	611- 620	3,870	4,180	224,960	229,080	58.1	54.8	71.1	73.0
59	633- 631	5,460	3,240	292,140	169,920	53.5	52.4	125.8	100.1
61	654- 655	3,550	3,840	214,860	239,520	60.5	62.8	69.7	80.8
Sums		66,240	57,590	2,862,110	2,715,930	554.9	594.7	962.2	905.5
Means		5,520	4,799	238,509	226,328	46.2	49.6	80.2	75.5
Red River to Scot Bluffs:									
63	686- 684	4,030	4,650	253,040	241,660	62.7	51.9	71.9	62.9
65	720	3,010	2,990	197,080	191,480	65.4	64.0	90.5	88.3
67	757- 758	6,370	6,590	237,440	240,040	37.2	36.6	68.5	63.8
69	790- 789	3,880	3,320	236,360	196,800	60.9	59.3	76.8	81.8
71	825	2,980	2,850	199,240	184,440	66.8	64.7	102.0	82.5
73	837- 838	2,620	2,690	192,400	190,280	73.8	70.7	105.5	87.6
75	858	4,860	4,750	225,860	234,120	46.5	49.3	69.3	71.5
77	882	2,750	2,920	178,560	192,880	64.9	66.0	85.1	80.4
79	900	2,830	3,040	192,880	161,320	68.1	53.0	81.0	80.6
81	917- 918	4,290	4,140	218,520	226,360	50.9	54.7	77.3	77.3
84	944- 945	2,550	2,680	160,840	176,760	63.1	65.9	92.5	86.4
Sums		40,170	40,620	2,292,220	2,236,140	660.3	636.1	920.4	863.1
Means		3,652	3,693	208,384	203,285	60.0	57.8	83.7	78.5
Scot Bluffs to Donaldsonville:									
86	964- 966	3,550	3,220	184,560	182,940	55.1	57.1	90.2	82.7
87	983- 984	3,510	3,820	199,520	209,080	56.8	54.8	77.5	75.0
89	1009-1010	2,650	3,040	175,160	185,880	66.1	61.1	81.6	75.0
91	1025	3,430	3,050	195,720	187,760	57.1	61.6	80.5	79.6
93	1047-1046	4,360	3,520	219,520	195,840	50.3	55.6	78.2	74.8
95	1068-1066	3,100	2,670	190,040	179,140	61.3	67.1	93.0	80.2
97	1086-1085	3,190	2,900	156,900	173,400	49.2	59.8	76.8	72.8
99	1103	2,790	2,940	172,120	184,160	61.7	62.6	80.0	74.1
Sums		26,580	25,160	1,493,540	1,498,200	457.6	479.7	657.8	614.2
Means		3,322	3,145	186,692	187,275	57.2	60.0	82.2	76.8

TABLE No. 11.—*Comparison of cross-section elements—Summary of changes i sections between years of 1883–1896.*

REMARKS.—The division of the river into bends and crossings is to a certain extent arbitr The crests of the bars are generally not coincident in the two surveys, having moved dow since the earlier survey. In these cases the crossing stretches have been extended to cover t of both bars.

The comparative changes in bends and crossings might be altered slightly by a different ment of these stretches.

Shoal reaches have been included under the head of crossings.

REACH 1, FROM VICKSBURG TO NATCHEZ.

	Bends (223 sections; 49.5 miles).	Crossings (145 sections; 38.3 miles).	Entire river tions; 87.8
At low water:			
Width decreased	84 feet, or 4.6 per cent.		62 feet, or 3.2
Width increased		252 feet, or 12 per cent.	
Area increased	800 square feet, or 1.5 per cent.	1,472 square feet, or 3.1 per cent.	1,094 square 2.2 per cen
Mean depth increased	1.2 feet		
Mean depth decreased		2 feet	0.2 foot.
Maximum depth increased	3.5 feet		0.9 foot.
Maximum depth decreased		2.6 feet, or 6.9 per cent.	
At medium stage:			
Width increased	84 feet, or 2.1 per cent.	423 feet, or 10.1 per cent.	230 feet, or cent.
Area increased	1,765 square feet, or 1.3 per cent.	5,953 square feet, or 4.1 per cent.	3,592 square 2.5 per cen
Mean depth increased	0.2 foot		
Mean depth decreased		1.7 feet	0.7 foot.
At bank-full stage:			
Width increased	671 feet, or 14.2 per cent.	504 feet, or 9.9 per cent.	598 feet, or cent.
Area increased	6,048 square feet, or 3.4 per cent.	14,103 square feet, or 6.8 per cent.	10,070 square 4.9 per cen
Mean depth decreased	2.4 feet	1.5 feet	2.2 feet.

REACH 2, FROM NATCHEZ TO RED RIVER.

	Bends (205 sections; 39 miles).	Crossings (120 sections; 24.1 miles).	Entire river tions; 63.1
At low water:			
Width increased	109 feet, or 5.4 per cent.	265 feet, or 11.4 per cent.	168 feet, or cent.
Area decreased	1,433 square feet, or 2.3 per cent.	3,028 square feet, or 5.1 per cent.	2,043 square 3.3 per cen
Mean depth decreased	1.9 feet	4.4 feet	2.8 feet.
Maximum depth decreased	5.2 feet	5.3 feet	5.2 feet.
At medium stage:			
Width increased	49 feet, or 1.3 per cent.	42 feet, or 1 per cent.	46 feet, or 1.2
Area decreased	4,188 square feet, or 2.9 per cent.		2,062 square 1.4 per cen
Area increased		1,389 square feet, or 0.9 per cent.	
Mean depth decreased	1.2 feet	1.7 feet	1.5 feet.
At bank-full stage:			
Width increased	479 feet, or 11.4 per cent.	403 feet, or 8.1 per cent.	450 feet, or cent.
Area increased	4,319 square feet, or 2.1 per cent.	5,251 square feet, or 2.4 per cent.	4,675 square 2.2 per cen
Mean depth decreased	3.9 feet	4 feet	4 feet.

REACH 3, FROM RED RIVER TO SCOT BLUFFS.

	Bends (190 sections; 44.8 miles).	Crossings (78 sections; 18.3 miles).	Entire river tions; 63.1
At low water:			
Width decreased	112 feet, or 5.2 per cent.		44 feet, or 1.9
Width increased		124 feet, or 4.7 per cent.	
Area decreased	6,793 square feet, or 7.7 per cent.	3,265 square feet, or 4 per cent.	5,770 square 6.8 per cen
Mean depth decreased	3.8 feet	3.3 feet	2.1 feet.
Maximum depth decreased	7.6 feet	5.5 feet	7 feet.

TABLE NO. 11.—*Comparison of cross-section elements—Summary of changes in mean sections between years of 1883–1896*—Continued.

REACH 3, FROM RED RIVER TO SCOT BLUFFS—Continued.

	Bends (190 sections; 44.8 miles).	Crossings (78 sections; 18.3 miles).	Entire river (268 sections; 63.1 miles).
At medium stage:			
Width increased	36 feet, or 1.1 per cent.	68 feet, or 2 per cent.	45 feet, or 1.5 per cent.
Area decreased	7,238 square feet, or 4.6 per cent.	2,794 square feet, or 1.8 per cent.	5,949 square feet, or 3.8 per cent.
Mean depth decreased	3.8 feet	1.8 feet	3.2 feet.
At bank-full stage:			
Width increased	64 feet, or 1.8 per cent.		37 feet, or 1 per cent.
Width decreased		29 feet, or 0.8 per cent.	
Area decreased	6,671 square feet, or 3.3 per cent.	1,919 square feet, or 0.9 per cent.	5,295 square feet, or 2.6 per cent.
Mean depth decreased	3.4 feet	1.4 feet	2.9 feet.

REACH 4, FROM SCOT BLUFFS TO DONALDSONVILLE.

	Bends (97 sections; 33.3 miles).	Crossings (73 sections; 24.8 miles).	Entire river (170 sections; 58.1 miles).
At low water:			
Width increased	46 feet, or 2 per cent.	123 feet, or 4.8 per cent.	79 feet, or 3.2 per cent.
Area decreased	9,181 square feet, or 7.5 per cent.	2,439 square feet, or 2.3 per cent.	6,303 square feet, or 5.5 per cent.
Mean depth decreased	3.9 feet	3 feet	3.5 feet.
Maximum depth decreased	7.3 feet	5.8 feet	6.6 feet.
At medium stage:			
Width increased	144 feet, or 5.5 per cent.	253 feet, or 9 per cent.	190 feet, or 7 per cent.
Area decreased	4,631 square feet, or 2.8 per cent.		3,390 square feet, or 2.1 per cent.
Area increased		292 square feet, or 0.2 per cent.	
Mean depth decreased	6.9 feet	7.5 feet	7.1 feet.
At bank-full stage.			
Width decreased	54 feet, or 1.8 per cent.		
Width increased		96 feet, or 3.2 per cent.	12 feet, or 0.4 per cent.
Area decreased	2,351 square feet, or 1.2 per cent.		1,352 square feet, or 0.7 per cent.
Area increased		796 square feet, or 0.4 per cent.	
Mean depth increased	0.5 feet		
Mean depth decreased		1.4 feet	0.3 foot.

GRAND SUMMARY OF CHANGES IN MEAN SECTIONS BETWEEN YEARS OF 1883–1896, VICKSBURG TO DONALDSONVILLE.

	Bends (715 sections; 166.5 miles).	Crossings (416 sections; 105.6 miles).	Entire river (1,131 sections; 272.1 miles).
At low water:			
Width decreased	21 feet, or 1 per cent.		
Width increased		203 feet, or 8.6 per cent.	65 feet, or 3 per cent.
Area decreased	3,823 square feet, or 4.9 per cent.	1,294 square feet, or 1.9 per cent.	2,805 square feet, or 3.8 per cent.
Mean depth decreased	1.3 feet	3.1 feet	2 feet.
Maximum depth decreased	3.7 feet	4.4 feet	4 feet.
At medium stage:			
Width increased	74 feet, or 2.2 per cent.	234 feet, or 6.3 per cent.	136 feet, or 3.8 per cent.
Area decreased	3,211 square feet, or 2.1 per cent.		1,165 square feet, or 0.8 per cent.
Area increased		2,058 square feet, or 1.4 per cent.	
Mean depth decreased	2.6 feet	3.1 feet	2.8 feet.
At bank-full stage:			
Width increased	319 feet, or 8 per cent.	293 feet, or 6.8 per cent.	308 feet, or 7.5 per cent.
Area increased	692 square feet, or 0.3 per cent.	6,167 square feet, or 3.1 per cent.	2,816 square feet, or 1.4 per cent.
Mean depth decreased	2.6 feet	2 feet	2.3 feet.

TABLE NO. 12.—*Showing for each survey the length of river where the cross-secti*
ments of one survey exceed those of the other.

	Width.		Area.		Mean depth.		Maxi dep
	Greatest in 1882-83.	Greatest in 1895-96.	Greatest in 1882-83.	Greatest in 1895-96.	Greatest in 1882-83.	Greatest in 1895-96.	Greatest in 1882-83.
First reach (Vicksburg to Natchez, 87.8 miles):	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*
Low water	38.9	48.9	38.2	49.6	44	43.8	41.8
Medium stage	37.5	50.3	37.8	50	41.3	46.5	....
Bank-full stage	29.9	57.9	35.3	52.5	55.7	32.1	....
Second reach (Natchez to Red River, 63.1 miles):							
Low water	24.3	38.8	30	33.1	36.9	26.2	36.4
Medium stage	30.4	32.7	31.2	31.9	27.4	35.7	....
Bank-full stage	16.1	47	28.1	35.0	42	21.1	....
Third reach (Red River to Scot Bluffs, 63.1 miles):							
Low water	31.5	31.6	39.2	23.9	37.9	25.2	42.7
Medium stage	22.7	40.4	41.3	21.8	42.4	20.7	....
Bank-full stage	20.9	42.2	38.8	24.3	45.1	18	....
Fourth reach (Scot Bluffs to Donaldsonville, 58.1 miles):							
Low water	17.5	40.6	40.4	17.7	41.4	16.7	43.7
Medium stage	8	50.1	34.1	24	44.8	13.3	....
Bank-full stage	19.8	38.3	29.9	28.2	31.9	26.2	....
Total (Vicksburg to Donaldsonville, 272.1 miles):							
Low water	112.2	159.9	147.8	124.3	160.2	111.9	164.6
Medium stage	98.6	173.5	144.4	127.7	155.9	116.2	....
Bank-full stage	86.7	185.4	132.1	140	174.7	97.4	....

CARE AND REPAIR OF DREDGING PLANT.

At the date of the last report the dredge *Alpha* and one barge were being ca
in winter quarters at Memphis, Tenn. By the end of June the dredging pl
charge of the secretary was increased by transfer from the first and second di
as follows: One towboat, *Minnetonka;* 1 quarterboat, No. 13; 1 pile driver, No
fuel flat; 2 barges. From the third district: One towboat, *Vidalia;* 1 pile drive
33; 1 barge, No. 207.

During the month of May, 1897, the plant was further increased by the foll
transfers: From first and second districts, barges Nos. 201, 205, 214, and 219; fro
third district, barges Nos. 208, 211, 215, and 228, pile sinker No. 61, and mac
for 4 pile sinkers.

Assistant Engineer Peter Mogensen was placed in charge of the *Alpha* and
on July 31, and continued in charge until the plant was placed in winter quar
East Cairo.

Repairs preliminary to field operations, and the care and repair of the entire
at East Cairo, have been in charge of Assistant Engineer C. W. Sturtevant.

During May and June, 1896, the following repairs were made on the dredge
The hull was calked and painted; the furnace walls and fire-door liners
renewed; main pump and engine were lined up and new keys provided. All
other machinery was overhauled; new hose couplings were put in the jet-disc
pipe; the floating pipes were scraped and painted; the smokestacks were pa
also the laundry and kitchen floors. The hull is now being repaired where de
and arrangements are being made to put in a new main pump.

The contractor made the following repairs on the dredge *Beta*, at his own ex
during the months of July and August: An additional expansion joint was
the main steam pipe; extra brackets were put on the floating discharge pipe
new coupling bars, hose clamps, and hose were provided; the deflecting app
and stern davit were repaired; hand capstans were put on each line of floatin
for use in deflecting same; the cutters, cutter shafting, bearings, and gear
were repaired; hose couplings to journal pipes were lengthened; ladder bail
cased to protect main cables from abrasion; new grate bars were put in, filte
were renewed, and cracked piston head in low-pressure cylinder of cutter e
was replaced by a new one; five anchor piles were straightened; new globe
were placed in each branch steam pipe connecting boilers, four in all; bedpl
spud engines was repaired and numerous minor repairs and changes of pipe
valves were made by the contractor.

The repairs made on the *Beta* under the direction of the Secretary were as fo
The starboard main engine was lined up, steam joints renewed, and valves regr
the cutter-engine shaft was cut near center bearing and united by doubl

coupling, so as to simplify the matter of repairs to gear wheels, etc.; a pine collision bulkhead was built 9¼ feet from the bow as a precaution against sinking in case of damage to the hull by accidents to the cutters. During the winter the filter beds have been renewed and strengthened; plungers of feed pumps have been turned down, valves reground, and steam joints renewed; the starboard main-pump runner was replaced by a new one; six-drum hoist has been overhauled and put in order, with the exception of the friction blocks and pawl teeth; the roof, cabin bulkheads, and smokestack casings have been repaired; sides and bottom of forward compartments and boiler room of hull have been scraped and painted.

In view of the proposed widening of the hull to secure less draft, the cutters, with shafting, ladders, etc., and extension stacks, have been removed, and valves, engines, and pumps have been dismantled ready for repairs when repairs to hull are completed.

Steamer *Minnetonka* received the following repairs: New sheets were put in boilers where required and furnace walls were rebuilt; the doctor was repaired and put in good order; the wheel was thoroughly overhauled and defective parts replaced with new material; seventeen new floor timbers were put in; five new fenders were made, the ends of carlins and the top and bottom plank shear were renewed where necessary; the roof was patched and the entire boat was repainted.

The steamer *Vidalia* has received such temporary repairs as will make her serviceable for another season. Roof, skylights, and windows have been overhauled and made water-tight; a new head has been put on, and boiler deck, hand rail, splash bulkhead, guards, and capstan have been repaired.

Quarter boat No. 13 was provided with a new ice box, and the interior bulkheads were changed and bunks put in to adapt the boat to the wants of the dredging crew. Minor repairs were made to deck and roof, and interior of dining room was painted.

Minor repairs to the leads, hull, and machinery were made on pile sinker No. 21.

On pile sinker No. 33 the leads were repaired and the small hoisting engine was replaced with a large double engine received from first and second districts. The hull was repaired sufficiently to keep the boat in serviceable condition.

Barge No. 153 was utilized as a shop boat for the *Beta* by the construction of a cabin 56¼ feet long. In this shop were erected lathe, drill press, emery grinder, crank shaper, forge with blower, and an engine to run this machinery.

Barge No. 66 was calked and patched sufficiently to make it serviceable. This barge was sunk during the storm of March 5, but will be recovered when the water falls.

Barge No. 207 was used as fuel barge for the *Beta*. It was in bad order, but was patched and calked so that it would answer for temporary use.

The two fuel flats used with the *Alpha* only required calking. The plunder flat used to carry piling with pile sinker No. 33 was patched and calked and a new deck was laid. This flat can not be used another season and is not worth repairing.

The measuring barge was taken to St. Louis, where it was docked and repaired. One of the 33-inch inlet pipes was replaced by one of 34 inches in diameter. The blow-out valves and trip valves were repaired and pressure pipes lengthened.

A new calking flat for facilitating work around the fleet was constructed. Other minor work was done in the construction of ladders, run plank, stages, etc., and in repairs of skiffs.

Repairs made while dredges were at work are given under "Dredging operations."

Table of care and repairs of dredging plant to June 1, 1897.

Care of plant	$9,724.23
Repairs of—	
Dredge *Alpha*	1,728.21
Dredge *Beta*	4,274.38
Quarter boat No. 13	667.71
Steamer *Minnetonka*	1,261.98
Steamer *Vidalia*	691.55
Pile sinker No. 33	170.12
Pile sinker No. 61	16.62
Pile sinker No. 21	156.41
Barge No. 153, shop boat	594.84
Barge No. 66	77.85
Barge No. 201	11.14
Barge No. 207	211.35
Barge No. 208	15.18
Fuel flat with *Alpha*	28.22
Fuel flat with *Beta*	32.13
Plunder flat	49.29
Measuring barge	1,088.06
Miscellaneous	219.95
Total	21,019.22

NEW DREDGES.

Contracts for the construction of two new dredges—the *Gamma* and *Delta*
completed, and their construction was begun early in June, 1896.

The construction of the *Gamma* was awarded to the Bucyrus Steam Shov
Dredge Company, of South Milwaukee, Wis., on their bid of $85,530.60. Th
tract was approved by the Chief of Engineers on July 25, 1896.

The construction of the *Delta* was awarded to the New York Dredging Co
of New York City, at $124,940. The contract was approved by the Chief o
neers September 19, 1896.

The general specifications for these dredges will be found in the proposals
in the report of 1896, pages 3467–3472.

Proposals for constructing the dredges *Epsilon* and *Zeta* were opened on No
11, 1896, and the contract was awarded to the Springfield Boiler and Manufa
Company, of Springfield, Ill. The general specifications will be found in the
sippi River Commission report for 1897.

The contract price of the *Epsilon*, which is provided with water-jet agita
$102,000, and for the *Zeta*, provided with mechanical agitators, $106,000. T
tract was approved by the Chief of Engineers on December 31, 1896.

The Gamma.—The hull of this dredge is constructed of steel, and is 138 fe
38 feet wide, and 8 feet in depth. The bow has a well for the suctions 32¼ fe
22 feet wide at the bow, and 16 feet wide at the rear end of the well. The tw
of the hull at the bow are connected and stiffened by a box girder 18 by 36 in

The hull framing consists of 12-inch channel iron floors stiffened with
keelsons. Bulkheads are put in, dividing the hull into two compartments—
the boilers and coal, the other for the engines. Surrounding these compar
are water-tight spaces decked over and used for storerooms and sundry suppl

The cabin is 97 feet long and 29 feet wide. The quarters for the crew, wit
rooms, storerooms, mess rooms, galley, etc., are above the boiler deck. The
surrounded by a covered guard 3½ feet wide. Between the boiler and engin
on the main deck is located the repair shop, fitted with lathe, drill press, v
other appliances needed in making ordinary repairs.

There are six boilers 48 inches in diameter, 28 feet long, with five 11-inch
each. These boilers are tested to carry 140 pounds of steam, and are arra
two batteries, so that they can be used separately if need be.

Fire bed and ash pan rest directly on keelsons. In the boiler compartn
front of the boilers are coal bunkers of 40 tons capacity.

The bottoms of the mud drums are below the water line; hence a special c
device is provided in the shape of a special tank set on the frames between t
sons under the mud valves. The water and mud remaining in the drums be
water line are drawn off in this tank and are then siphoned out.

The feed water is heated by passing through two pipes hung in brackets f
sides of the parting wall between the two battery furnaces.

The ash chute passes through the compartments adjoining the boilers and t
the gunwale just above the water line. The chutes are inclined, and are p
with doors at the inner end.

The main dredging pump is in the forward part of the engine room, its be
connected to the keelsons. This is a centrifugal pump with double suction i
inches in diameter. The casing is cast iron from 1¾ to 2¼ inches thick. The
is split horizontally through the axis so the upper half can be removed for
The shaft bearings are 8 inches in diameter. The pump runner is 5 feet 9 in
diameter and has 4 blades. The capacity of this pump at 146 revolutions a
anteed by the contractor is 800 cubic yards of sand per hour based on a velo
10 feet per second, 10 per cent of sand and 90 per cent of water delivered t
1,000 feet of floating pipe with suction 15 feet below the water line.

The 34-inch discharge pipe is at the bottom and the intake comes in at ea
of the pump through two 24-inch pipes leading from the suction head. T
charge pipe runs along the 12-inch channels between two central keelsons un
partition wall between the batteries and through the stern with its cente
above the bottom of the boat at the exit. The top of the discharge pipe n
pump is depressed below the water line and the pump is primed by mea
steam siphon at the top of the pump casing. The floating discharge pipe i
feet long and is made in 20 sections of 50 feet each. The discharge pipe is 34
inside diameter and is made of tank steel one-fourth inch thick. Each pipe
vided with cleats and brackets for supporting the running board. These pi
floated by means of 40 pontoons 23 feet 9 inches long and 30 inches in diam
cylindrical form, made of tank steel three-sixteenths inch thick and provide
manhole at one end. These pontoons are attached to discharge pipes by m
truss frames constructed of heavy bar and angle iron so designed as to rece
clamp the pipe and carry the pontoons on either side. The floating discha
is attached to the hull discharge by means of a male and female beveled

coupling, a davit being used to swing the floating pipe into position and leaving all of the movable clamping parts above the water line.

The shaft bearing in the pump casing is lubricated by a compression grease cup operated by the engine.

The two intake pipes run forward to the suction head. They are hinged to the boat by two flanges connected by a pivot pin on the lower side and provided with circular stuffing box, making a radial joint that will allow suction to be lowered to a depth of 15 feet. Outside of the hinge the pipes and suction head are trussed together and rigidly connected so as to form essentially one piece. The two intake pipes extending to the suction heads are 11 feet apart from center to center. There is a suction head 8 feet long for each intake pipe. These heads are 3 feet apart, and together form one suction head 19 feet long over all.

The suction head proper has two inlets, one for an upper and one for a bottom intake, while between the two is a triangular pressure chamber reaching the full length of the head and connected directly with the jet pump. This chamber has nine 2½-inch nozzles through which the water from the jet pump is forced with sufficient pressure to loosen the sand in front of the suction.

The main engines are of the horizontal cross-compound type, condensing and provided with independent condenser. The cylinders have large steam and exhaust passages and slide valves. The high-pressure cylinder is provided with a Meyer adjustable cut-off mechanism, with hand adjustment to regulate point of cut-off. Low-pressure cylinder has expansion relief valves.

The high and low pressure engines are connected to two disk cranks set at right angles and keyed to opposite ends of the shaft of the main pump. The high-pressure cylinder is 18 inches diameter by 22 inches stroke, and is provided with Gardiner throttling governor and adjustable valve movement. The low-pressure cylinder is 32½ inches diameter by 22 inches stroke, and receives steam from the high-pressure cylinders. Both cylinders are connected as a cross compound engine.

The engines rest on individual sub-bases belted to the pump base and all fastened to the keelsons.

The estimated power of the engines under ordinary conditions of 140 pounds boiler pressure and 150 revolutions is 500 horse power, with ultimate capacity of 700 horse power.

The centrifugal jet pump is located adjacent to the high-pressure engine. This is an 18-inch pump that supplies the water to stir up the sand at the suction head. The casing is split vertically. The runner has 4 arms with steel plates riveted to them, giving the least possible amount of clearance between them and the casing, so as to produce the greatest practicable pressure. It has one intake and discharges through an 18-inch pipe to the nozzle chamber in the suction head. A section of the discharge pipe outside of hull is made of rubber hose, to allow it to conform to the motion of the suction head.

The jet pump and engine are self-contained and rest on a common bedplate and have a flange-coupled shaft for pumps and engine.

The jet-pump engine is of the vertical compound marine type, condensing, with high-pressure cylinder 12 inches in diameter, a low-pressure cylinder 22 inches in diameter, and both having 14 inches stroke. The cylinders are provided with plain slide valves. The crank shaft, with double cranks set at right angles, is made of a heavy angle forging of the best class of steel. The engines are provided with complete automatic apparatus for thorough lubrication.

The air pump and jet condenser are located adjacent to the low-pressure main engine. The air pump is of the horizontal type, having single steam cylinder 10 inches in diameter and air cylinder 18 inches in diameter, with 18 inches stroke.

The condenser receives the steam from both main and jet pump engines, and is so arranged that the steam can pass direct to the atmosphere. The overflow from the condenser passes through a chamber, forming a hot well for the feed-water pumps.

Two feed pumps and one fire pump are so constructed that any one can be connected to feed-water pipe on fire hose. These pumps are vertical, duplex, outside packed plunger pumps having 7½ inches diameter of steam cylinders, 4½-inch water plungers with 8-inch stroke.

The filter is operated by a separate pump. It is an ordinary sand filter with alum as a coagulant. The water is pumped through the filter to tank on roof, from which it is piped to various parts of the cabin.

The electric-light plant consists of a 7 by 10 Ideal engine and belt-connected multipolar dynamo. The current supplies one Huntington search light of 4,000 candlepower, 4 arc lights of 1,200 candlepower, and 75 incandescent lamps of 16 candle power. The search light is provided with both vertical and horizontal adjustments.

Power is taken from this engine to drive the shafting of the repair shop.

The winding drums, speed hoist, and their engines are located at the forward end of the boat under an extension of the cabin. The operating stand is centrally located in the group.

The main winches are located on opposite sides of the boat near the guards. They are driven independently and are provided with fast and slow feed controlle clutches. Each drum, 42 inches in diameter and 42-inch face, has a capacity of 1 feet of ⅞-inch wire rope. Each drum is driven by a pair of double cylinder 7 engines of the dummy locomotive type with cam reverse, and transmit their po through a combination of worm and spur gearing. The spur gearing is fitted w two speed on an intermediate shaft which is also provided with a brake wheel brake strap. The ratio of speed is 493 to 1 for slow speed and 81 to 1 for high sp

The hoisting engine for raising suction pipe is just back of the spud and oper a shaft that terminates in a spool at each end near the guards. These spools ma used for hauling in lines in lieu of capstans. The shaft also carries a gear clutch, operating a drum for the line leading through top of A-frame to suction h The drum is 24 inches in diameter, with 24-inch face, and is fitted with brake b spur gear, pinion clutch, and shifting device. It is driven by a pair of horizo double cylinder, 8 by 10 inch, plain slide-valve engines provided with steam reve

All winch drums are provided with friction band brakes. The spud is hoiste means of a single-acting steam cylinder, 18 inches in diameter, 6-foot stroke, st ing upright with the piston attached to a cam clamp at its upper end, and w grips and holds the spud against the slides. Steam is admitted to the bottom o cylinder through a three-way valve, raising the piston and spud to the height o movement. When the valve is turned to the exhaust port, the piston and cl descends. The spud is supported by a rack and pinion on the after side and the p locking the pinion is hinged between its center of movement and point, and tripping is effected by making the pawl to buckle on itself when its point t under, releasing its hold, which allows the spud to drop.

The entire control of winding machinery, spud hoist, and search light is effe from an elevated platform with properly connected levers, throttle valves, etc.

The tools for repair shop consist of 1 Reed compound back geared lathe, 20- swing, 10-foot bed, with chuck and change gear. One Prentice back geared press, 25-inch swing, countershafts, and pulleys for operating the above. Ther also provided a bench, forge, and blower, blacksmith's tools, pipe tools, and o tools needed in making minor repairs.

There are 4 hydraulic piles, 10 inches in diameter, and 4 that are 12 inche diameter, all 33 feet long. They are made of extra heavy wrought-iron pipe an provided with cast-iron heads for raising them and also with hose connections.

The subcontractors on the above work were as follows:

Hull and cabin, E. J. Howard, Jeffersonville, Ind.

Boilers, Charles Hegewald Co., New Albany, Ind.

Electric-light engines, A. L. Ide & Sons, Springfield, Ill.

Feed and fire pumps and air pump with condenser, Prescott Steam Pump Co., waukee, Wis.

Electric generator, searchlight, lamps, and installation, Gibbs Electric Co., waukee, Wis.

Lathes and drill press, Manning, Maxwell & Moore, Chicago, Ill.

Capstans, Providence Capstan Works, Providence, R. I.

Floating discharge pipe line and pontoons, Freeman Bros., Racine, Wis.

The Bucyrus Steam Shovel and Dredge Company constructed the follo machinery at their shops in South Milwaukee, Wis.: Main engines and pumps pump and engines, auxiliary engines and winches, spud cylinder and attachm suction head, radial joints, pipe and framing, suction and discharge pipes in suspension tackle for suction head and pipe, traveling crane and trolley hoists, frame and attachments for floating discharge pipes, hydraulic piles.

The construction of the hull was begun on the ways on July 25, and it was p tically completed by the end of September, with the exception of painting placing the spud guides. It was launched on November 9. The hull, with the sections of suction and discharge pipe, showed a draft of 18 inches forward 12 inches aft.

The boiler construction was begun August 11 and completed October 1. erection of boilers, chimneys, etc., was begun during the second week of Novem and the work was practically completed by December 20.

The cabin was begun on December 1, and was completed, except painting, by uary 16.

The construction of the machinery was begun by the Bucyrus Company in J 1896, and all shop work was completed by the end of January.

The erection of machinery on the dredge was begun at Jeffersonville, Ind., Oct 13, and was practically completed at the end of February.

On March 29 the contractor reported the dredge ready for testing. Owing t high stage of river, the tests were necessarily postponed.

The dredge arrived at Cairo, Ill., on April 28, and the galley, mess room, ca and other outfit needed for the accommodation of the crew was put on boar May 31.

The weights of material entering into the construction of the *Gamma* are as follows:

	Pounds.
Hull	328, 328
Cabin	117, 449
Main pump and engines	74, 722
Jet pump and engines	21, 717
Auxiliary engines, drums, levers, etc	46, 937
Air, feed, and fire pumps	15, 695
Electric-light plant	7, 700
Boilers, etc	325, 911
Suction head	49, 584
Hull fittings	31, 580
Total	1, 019, 623

The floating discharge pipes and pontoons weigh 244,916 pounds without the winch, running board, or brackets. The piles weigh 13,822 pounds.

The draft of the dredge in working condition will be about 45 inches forward and 47 inches aft.

The shop work at South Milwaukee, Wis., and the construction of the pipe line at Racine, Wis., was all done under the supervision of George H. Hewes as inspector on the part of the United States.

The construction of hull, cabin, and boilers, and the erection of machinery was under the supervision of Benjamin F. Crow as inspector on the part of the United States.

The data here presented with reference to the *Gamma* is compiled from the detailed reports of the inspectors.

The Delta.—The hull of this dredge is constructed of steel, and is 175 feet long, 38 feet wide, and 8½ feet deep. The deck has a crown of 3 inches. The midship section of hull is rectangular, and the ends have a short rake. At the bow a fender 24 feet long is carried completely around the suction head. This fender carries the frame from which the suction heads are raised and lowered. The frames of hull are spaced 22 inches between centers, with Z-bar floors and angles for deck beams. There are two longitudinal bulkheads extending the full length of the hull, made of 5/16-inch plate, with double angles top and bottom, and made water-tight. There are five water-tight cross bulkheads made of 5/16-inch plate. There is a syphon in each compartment.

The sides of hull are of steel plates ⅜ inch thick. All other plating of hull proper is 5/16 inch thick. The plating on outside of hull is laid fore and aft and is single riveted and lapped, except on deck, where seams are planed and butted and fastened with butt straps 6 inches wide single riveted. Cross seams are similarly butted and fastened.

Special foundations of 12-inch I beams are put in to sustain main engine, boilers, winding and excavating machinery; also special foundation of plates and angles for engine.

The hull is provided with the necessary hatches, kevils, chocks, and other fittings.

The cabin is 156¼ feet long and 31 feet wide, the quarters for crew being chiefly on the boiler deck. The space on main deck between boilers and engines is also utilized for sleeping and mess room for part of the crew. Forward of the cabin there is an extension of the boiler deck and roof of 12 feet, making a room for the operator, with the levers, clutches, throttles, etc., used in operating the winding machinery and hoists.

The cabin is divided into officers' quarters, mess rooms, galley, laundry, storerooms, sleeping room for crew, bathrooms, etc.

There are 4 Heine safety boilers, rated at 250 horsepower each. Each boiler consists of 2 shells 36 inches in diameter and 19 feet 4 inches long, 2 water legs of flanged and riveted sheets held by hollow stay bolts, 140 lap-welded boiler tubes 3¼ inches in diameter, 16 feet long, and 1 submerged internal removable mud drum in each shell.

The boilers were tested at the shop under a pressure of 240 pounds. They are fully equipped with the necessary safety valves, gauges, feed valves, etc.

The boilers are erected on the main deck near the after end of the boat, and are arranged in two batteries, with steam pipes and valves, which admit of cutting out a boiler if necessary. The stacks are 64 feet high above the grate, and there is one 66-inch stack for each battery.

The feed water is heated by passing through a Wainwright heater with shell 3 feet 1¼ inches in diameter. This shell is ⅜ inch thick and is riveted to cast-iron rings top and bottom, fitted with 114 corrugated copper tubes 1¼ inches in diameter and 78 inches long. These tubes are secured to iron tube plates 3 inches thick.

The steam pipe is 6 inches in diameter, the feed pipe 4 inches, and the drip, blow-off, and safety pipes are 2 inches in diameter.

The heater is situated in the center of the boat between the boilers and main en and near the latter. It is supported by cast-iron legs resting on the deck, and st 11 feet 4¼ inches high over all.

The main pump is of the centrifugal pattern, with a cast-steel runner 7 feet in d eter and 22 inches wide. The axis of this pump stands over the center line o hull, and is parallel thereto. The shaft is about 30 inches below the main deck. casing is made in four sections, with large flanges and side brackets to facilitate ing together and securing pump in position.

The cross section of casing is rectangular, with an effective width of 29 in The thickness of sides is 2 inches and the edges are 3 inches thick. The casi lined with steel in removable sections, held in place by means of bolts with cou sunk heads. The runner shaft is of forged steel, 7½ inches in diameter and 7 f inches long, and is fitted to the runner by tapered joint and secured in place by nut and two keys.

The shaft has but one bearing, and this is provided with water bushing to pre the sand from cutting the shaft.

The intake enters the pump at the forward side, and at the casing is 34 inch diameter. The discharge is on the starboard side of the pump, at right angles t intake and at the bottom of the casing. The discharge rises so the center li slightly above axis of pump, and runs aft parallel to side of boat until it passe main engine, then it bends over to the axis of the boat and drops the center of about 11 inches below the water line, and then runs along under the boilers thr the stern rake, where the floating pipe is coupled on.

The suction pipe runs straight forward for a distance of about 25 feet, and divides into two pipes, each 24½ inches in diameter. These pipes separate and ex to the bow of the boat, passing through the rake 4½ feet each way from the c line and below the water line. Each pipe turns square along the bow to the and left for a short distance, and then turns out, and, again separating into two p each 17½ inches in diameter, connects with the suction head.

At the outer end of the suction head is a shaft 6⅞ inches square, which is reve by two split sprocket wheels 38⅞ inches in diameter, connected with cutter en shaft. On the cutter shaft are 22 cast-steel wheel cutters, each carrying four blades. These cutters revolve at a speed of about 100 feet per minute, and loose the material so that it can be taken up by the suction.

The cutter engine is a two-cylinder, nonreversible, horizontal type. The cylin 12½ inches in diameter and 15-inch stroke, have locomotive type of slide valve. are mounted on a semisteel cast frame, which slides in guides that are bolted foundation of ⅜-inch boiler plate securely fastened to forward part of deck. cutters are driven by means of suitable gearing and sprocket chains.

The floating discharge pipe is 1,000 feet long, and is made up in sections 50 fe length. It consists of a discharge pipe 34 inches in diameter supported by mea yokes attached to a floating pontoon, 26 inches in diameter on each side. The toon is horseshoe-shaped in section, with flat side uppermost. The discharge pi provided with a baffle plate at the end with which to deflect the pipe line.

There are six wrought-iron piles 10 inches in diameter and 38 feet long, and piles 6 inches in diameter and 25 feet long, fitted for use with hydraulic jet.

The main engine is a vertical inverted two-crank compound condensing engine, cylinders 22 and 48 inches in diameter, respectively, and 24-inch stroke, and has ton and slide valve, with adjustable cut-off for valve.

It is designed to develop 800 horsepower at 140 revolutions per minute, w boiler pressure of 160 pounds per square inch; vacuum, 25 inches.

The cylinders are supported by two cast-iron back frames of box section taper, steel, front columns 2¾ and 3¾ inches in diameter.

The bedplate is cast iron of the box girder pattern, and measures 8 feet 9 in long by 8 feet 9½ inches wide over flanges, and 20½ inches from center of sha planed bottom surface. It has 4 babbitted journal boxes 13 inches long by 8½ in in diameter. A gallery and stairway is provided to give access to the steam ch The engine is fully provided with drain cocks, relief valves, throttle valves lubricators.

The air pump and condenser is of the jet type, with steam cylinder 12 inch diameter, water cylinder 18 inches in diameter, and a common stroke of 24 in and has the condenser mounted vertically on the water cylinder. The air cyli is 18 by 24 inches, with copper-lined barrel, and plunger is packed with soft pack Valve seats are brass, pressed into place, and valves are of hard rubber. Cond has a brass spray cylinder, which throws the water out in jets.

The fire pump is duplex, with 2 steam cylinders 8 inches in diameter, and 2 plu 5 inches in diameter, with a stroke of 10 inches. The plunger, piston rods, p cylinder lining, with valve seats, are of brass, and plunger is packed with Tuck packing. The suction is 5 inches, and the delivery 4 inches, in diameter. This p furnishes water to all of the journals where water pressure is used to keep sand

Feed pump is of the duplex pattern, with two steam cylinders 7 inches in diam two plungers 4½ inches in diameter, with common stroke of 8 inches. The piston rod, plunger, pump-cylinder lining, and valve seats are of brass. The valves are of hard rubber.

There is one pressure filter of Jewell Filter Company's design; it is located on the port side, just forward of the boilers.

The shell is of steel, $\frac{7}{16}$ inch thick and 7 feet in diameter. The heads are dished, and top one has two manholes 10 by 16 inches. The washout pipe is 5 inches in diameter, and the other pipes are 3 inches in diameter. A special 3 by 4 inch Acme engine revolves a mixer by means of beveled gears and pulley attached to top of the filter, which stands 8 feet high. It has a guaranteed capacity of 65 gallons of muddy water per minute.

The electric plant consists of one 4-pole, 9-kilowatt, moderate-speed generator, made by the General Electric Company, two Thomson 1893 arc lamps, 100 16-candlepower incandescent lamps, one search light, voltmeter, ammeter, and double-pole knife switch. The generator is belted to a 7 by 9 vertical engine, and runs at a speed of 1,400 revolutions per minute.

The engine is used for lighting and running the machines in the repair shop. The fly wheel is 42 inches in diameter, with 7 inch face; and driving pulley is 48 inches in diameter, and 8 inch face. The engine is provided with all necessary valves, drain pipes, governors, oil cups, lubricators, etc.

There are two winding drums located forward of the main pump, one on the starboard and one on the port side of boat. Each drum is 42 inches in diameter and 42 inches long, mounted on a 6-inch shaft, with two bearings in main pillow blocks, and carries a 48-inch gear wheel at one end and an 84-inch gear wheel at the other end. These drums are operated through suitable gearing by two independent double-cylinder horizontal engines, with 10 by 12 inch cylinders. The same engines also operate the spud and ladder winches.

The ladder hoist for raising and lowering the suction head consists of a 24-inch drum 24 inches long and is located near the starboard side of boat, aft of the winding drum. The hoist drum is mounted on a shaft 4⅝ inches in diameter, which carries an 84-inch gear wheel at the starboard end. The rope from the drum leads up to the roof; thence out to sheaves at the top of the derrick frame at forward end of boat, directly over the end of the suction head.

The spud hoist is located near the port side of boat, aft of the port winding drum. The drum is 24 inches in diameter and 24 inches long, and is attached to a shaft 4⅝ inches in diameter, with a 48-inch gear wheel at the starboard end. The rope from the drum leads up to the roof; thence over sheaves to the spud, to which it is attached.

These winding and hoisting drums are provided with 4 Hill clutches, 6 post brakes, 4 complete jaw clutches, with the necessary operating rods and levers, which extend to the pilot house or operating room.

A hand-power traveling crane of 5 tons capacity is provided for handling and moving the winding machinery. A traveler is also provided for handling the pump, main engine, etc.

The repair shop is situated on the main deck, at the forward end of the boat, in front of the winches. It is equipped with 1 Bradford screw-cutting engine lathe, with 14-inch swing and 8-foot bed, 1 Barnes 22½-inch back-geared drill press, a blacksmith's forge, and full set of blacksmith's tools.

The various parts of the dredge above described were constructed by the following subcontractors:

Hull and floating pipe line: The Springfield Boiler and Manufacturing Company, Springfield, Ill. The plates for the hull and floating discharge pipe were rolled by the Schoenberger Steel Company; the angles and frames by Jones & Laughlin, both of Pittsburg, Pa.

Boilers: Heine Safety Boiler Company, St. Louis, Mo.

Heater: Taunton Locomotive Works, Taunton, Mass.

Filter plant: O. H. Jewell Filter Company, Chicago, Ill.

Fire and boiler feed pumps: Snow Steam Pump Works, Buffalo, N. Y.

Electric plant: New York Safety Steam Power Company built the engine; apparatus furnished by General Electric Company, New York.

Main pump engine: Brown & Miller, Jersey City, N. J.

Main dredging pump: Camden Iron Works, Camden, N. J.; cast steel runner was made by Franklin Steel Casting Company, Franklin, Pa.; shafts by the Cambria Iron Works, Johnstown, Pa.

Cutter and winding engines: Lidgerwood Manufacturing Company, South Brooklyn, N. Y.

Cutter and winding machinery: George V. Cresson Company, Philadelphia, Pa.; cast steel pinions and connecting links by the Chester Steel Casting Company, Chester, Pa.

Sprocket links, wheels, and cutter arms: Taylor Iron and Steel Company, High Bridge, N. J.

Steam capstans: Marine Manufacturing and Supply Company, New York.

Traveling crane and traveler: Brown Hoisting and Conveying Company, land, Ohio; the differential blocks, Yale & Towne.

Condenser and air pump: Laidlaw-Dunn-Gordon Company, Cincinnati, Ohi

Stratton separator: Goubert Manufacturing Company, New York.

The hull was constructed at Clifton Terrace, a short distance above Alte The first carload of material arrived at the Springfield works on September 1 and the hull was launched on February 20, 1897.

The cabin was constructed and the machinery erected by the New York Dre Company. The erection of cabin was begun March 22, and at the end of Ma practically completed.

The erection of machinery was begun on February 3, and it is expected th dredge will be ready for testing by the end of June.

The dredge was towed to St. Louis on May 17, and the finishing touches w put on at that point. Steam was raised on May 25, and the engines were star

The construction of the hull and floating pipe and erection of the machine been under the supervision of Julius L. Hornig, acting as inspector on the the United States. The construction of the machinery has been under the vision of P. H. Middleton, acting as United States Inspector. The descrip the dredge here given is largely derived from their reports.

The weights of the various parts of the dredge are about as follows:

	P
Hull	4
Main pump and engines	1
Cutter engines and machinery	
Winding engines and machinery, with extras	
Air pump and condenser, with extras, feed and fire pumps	
Electric plant, engine, dynamo, etc	
Heater, separator, and filter	2
Derrick, ladder, travelers, tackle, sheaves, bolsters, tools, etc	
Capstans, spud, piping and fittings, deck fittings, etc	
Discharge and suction pipes pertaining to hull	
Boilers, stacks, etc., complete	3
Cabin, complete	1
Spare parts for main pump	
Complete finished weight	1,3
Draft of boat (about)	4 feet 3 i
Weight of floating pipe line	221,477 p

EPSILON AND ZETA.

The work on these dredges was begun early in January, 1897, and the co requires their completion October 6, 1897. The *Epsilon* is to be constructe water-jet suction head, and the *Zeta* will be provided with mechanical agitato

The hulls are being erected at Grafton, Ill. All of the plates for hulls an lines have been received at Springfield, Ill. The general character of these d is set forth in the specifications printed as Appendix B, Report of Captain Waterman, Corps of Engineers, U. S. A., Secretary Mississippi River Comm for 1897.

The following subcontractors are engaged on this work: Structural steel: & Laughlin, Pittsburg, Pa.

Main dredging pumps and the jet pump and engine for the *Epsilon*: Morris M Works, Baldwinsville, N. Y.

Auxiliary engines and winches: Litchfield Car and Machine Works, Litchfie

Capstans: Bath Iron Works, Bath, Me.

Pumps: Laidlaw-Dunn-Gordon Company, Cincinnati, Ohio.

Rubber hose connections for pipe line: W. D. Allen & Co., Chicago, Ill.

Steel Castings: The Sargent Company, Chicago, Ill.

Engines: Ide Engine Works, Springfield, Ill.

More than three-fourths of the material for the hulls has been prepare forwarded to Grafton, Ill. Considerable progress has been made on the engin other machinery.

The hulls are being constructed under the supervision of Benjamin F. Crow, States inspector, and the machinery under the direction of George H. Hewes, States inspector.

Respectfully submitted.

J. A. OCKERSON,
Principal Assistant Engi

Capt. H. E. WATERMAN,
Corps of Engineers, U. S. A.,
Secretary Mississippi River Commission.

APPENDIX 7 E.

REPORT OF ASSISTANT ENGINEER C. W. STURTEVANT ON THE PROPER LOCATION OF DREDGE CUTS.

U. S. DREDGING FLEET, *Cairo, Ill., May 30, 1897.*

CAPTAIN: I have the honor to submit the following report upon the most important factor (location of dredge work) in the successful opening and retention of navigable channels through the bars of the Mississippi River during the low-water season by means of dredging:

The location of the dredged cuts is certainly of the most importance. With ever so large or efficient dredge, if the work is not located so as to receive the assistance of the current, the channel, even if opened, can not be retained.

The location of the work is governed by two questions: First, selection of channel, and second, location of the cuts in that channel.

At all places where dredging has been necessary there have been two or more channels, and the question of which shall be improved must first be settled. This matter has always been decided heretofore by examination of the different channels, taking into consideration the direction of current and form of submerged bars which first divide the channels.

Instead of examination by a reconnaissance, a survey should be made for at least 2 miles above the head of these dividing bars and down each channel at least a mile, as well as a survey of the shoal in each channel. The ranges sounded should be about 500 to 800 feet apart, except at each shoal, where they should be 250 feet apart. After deciding on the channel to be improved, the shoal in that channel should be carefully surveyed by ranges 100 feet apart, with soundings every 20 feet. These ranges should be about normal to the direction of the current, and together with the direction of surface floats and the expected stage will decide the exact location of the cuts.

The question of location of cuts may be divided into two parts: First, position; second, direction.

Position or point of cutting through the reef may be divided into two kinds, high and low. If the upper bar is high and will cut off much of the current from above as the river falls, the cuts must be located low down on the reef. If both upper and lower bars are high, so that as the river falls the direction of the current will be thrown more squarely across the river bed, then the cuts must be located high. If both upper and lower bars are flat, the cuts must be located according to shortest distance to be dredged and direction of current.

After the point of crossing the reef has been located, then the direction of the cuts must be decided upon. Direction may be divided into two classes, parallel and diagonal to the current. If as the river falls the line passing through the centers of gravity of the cross sections of the channel will remain in about the same position, the cuts should be made parallel to direction of the current; but if this line assumes an angle to the present line, the direction of the cuts should be changed so as to be nearer parallel to that line when the river falls, but not entirely so. This deflection may be either up or down.

Location of cuts should always be made in the early part of the season, with the idea in view that the river will fall. If this fall occurs, then all is well; if not, there will likely be sufficient depth through the channel for navigation.

Another and very important matter is the marking, not only of the channels dredged, but of other channels. A channel is often reported shoal owing simply to the boats not running in the proper place. Buoys put out on dredged bars are often moved by passing tows. Thus it would seem that the work of surveys and buoying of channels should be enlarged.

It is much cheaper to find channels and mark them than it is to dredge or have them reported shoal simply because the marks have been moved down off the reef by a tow or by some other cause.

I think every possible shoal should be visited twice a week and rebuoyed, if necessary, and that all channels should be surveyed, and the line of cuts to be dredged marked by a separate party, before the arrival of the dredge, at each bar.

Each dredge should have a small survey party, and there should also be a larger party, on a double-crewed steamer, to make general surveys. On this steamer might be quartered the superintendent of a certain district, who would have charge of all the dredges working in that district, and who would buoy out or locate the work to be done, as well as patrol and buoy the channels.

Very respectfully, your obedient servant,

C. W. STURTEVANT, *Assistant Engineer.*

Capt. H. E. WATERMAN,
Corps of Engineers, U. S. A.

Analysis of location of dredge work.

- Location of dredging.
  - Selection of channel.
    - Left.
    - Middle.
    - Right.
  - Location of cuts in channel
    - Point of crossing reef.
      - High.
      - Low.
    - Direction with current.
      - Parallel.
      - Diagonal..

APPENDIX 8.

REPORT OF CAPT. GRAHAM D. FITCH, CORPS OF ENGINEERS, UPON OPERATIO THE FIRST AND SECOND DISTRICTS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., May 1,

COLONEL: I have the honor to submit the following report of operations first and second districts for the year ending April 30, 1897:

FIRST DISTRICT (CAIRO TO FOOT OF ISLAND NO. 40, 220 MILES).

Columbus, Ky. (21 miles below Cairo).—In 1889 and 1890 five spur dikes of and stone were built along a caving bank in front of this place. These pro 2,200 linear feet of bank. This work at present is in fair condition, and has plished the object for which designed. Some caving has occurred in recent between the dikes where the bank was unprotected. No additional work is re at present.

Hickman, Ky. (26 miles below Cairo).—In 1889 a mattress of brush and sto feet long was placed along the bank in front of this town. This was repai various times, and the work extended downstream 630 feet, making the total of revetment now in place 1,560 feet. No further work is required at present.

New Madrid, Mo. (71 miles below Cairo).—The bank here had been rapidly for many years. In 1893 the bank along the upper portion of the town wa tected by 900 feet of fascine mattress 250 feet wide, and the upper bank Seven hundred linear feet of similar work was placed below this in 1894. The and harbor act of June 3, 1896, contained an appropriation of $16,000 for f improvement. This sum was expended in extending the revetment downstr distance of 500 feet, as the work already done is insufficient to hold the entire of the seriously caving bank. An additional extension should be made of a 1,000 feet.

(For further details, see report of Assistant Engineer Aug. J. Nolty.)

Summary of cost and of work done.

	Work done.	Cost per unit.	Tot
River mattress..........squares..	1,439.85	$6.81	$
Grading..........cubic yards..	11,436	.0291	
Paving..........square yards..	4,000	.703	2
Repairs to existing works..........do....	535.2	.282	
Total..........	....	....	1

Five hundred linear feet new work, at $25.906 per foot.

Material used per unit.

Items.	River mattress per square.	P
Brush..........cords..	1.72	...
Poles..........do....	.076	...
Stone..........cubic yards..	.966	
Wire:		
Strand..........pounds..	10.313	...
Annealed..........do....	2.796	...
Silicon bronze..........do....	.444	...
Staples..........do....	.118	...
Clips..........number..	1.03	...

Plum Point Reach (147 to 186 miles below Cairo).—The works of improvement in this reach have extended from Daniels Point to Craighead Point, Ark., a distance of about 20 miles. The operations have been fully described in previous reports. In general terms, the work done has been the protection of caving banks by the construction of 67,400 linear feet of revetment now in place, the closure of Gold Dust chute by means of pile dikes and a brush and stone dam, and the closure of Osceola and Bullerton chutes by means of pile dikes. The result of these works has been to give an increase of about 3 feet in depth over the crossings in Plum Point Reach during extreme low-water stage.

The work done during the past year is as follows: Towing 19,480 cubic yards of stone from quarries, 75 miles above Cairo, to Plum Point Reach, at a total cost of $8,006.36, or 41.2 cents per cubic yard. The price paid to contractor for delivery on United States barges at quarries was 46 cents per cubic yard.

Daniels Point.—A break occurred at about the middle of this revetment, or at the junction of the 1889 and 1895 revetments. This was at a projecting point in the bank, along which flowed an extremely rapid current. The cave was 400 feet long and extended into the bank at its maximum 120 feet. The plan for repairing this break, to prevent further enlargement, was to place a brush and stone crib dike on a mattress foundation at or about the middle of the break, this dike to extend to the deepest water. The sill, or floor mat, 200 feet long by 277 feet wide, was built and placed, but the rapidly rising river and strong current prevented the placing of the cribs as at first designed. They were therefore extended to only a few feet beyond the low-water line. Three cribs in all were built.

	Length.	Width.	Height at outer end.	Height at shore end.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Crib No. 1	111	30	8	7
Crib No. 2	121	20	8	6
Crib No. 3	119	10	6	4

The bank was then paved along each side of the cribs to prevent erosion.

The total cost of work was $11,750.73.

(For further details, see report of Assistant Engineer Aug. J. Nolty.)

Summary of cost and of work done.

	Work done.	Cost per unit.	Total cost.
Floor mattress .... squares..	739.6	$7.325	$5,417.84
Crib .... cubic yards..	1,365.8	4.341	5,929.87
Paving .... square yards..	742.5	.315	234.21
Grading .... cubic yards..	448	.376	168.81
Total	....	....	11,750.73

High cost of work is due to adverse conditions of river and weather.

Fletchers Bend.—The work done here during the year was the extension of the revetment southward and along the Luxora front to protect a rapidly caving bank, and the construction of a spur dike of brush and stone in the pocket opposite Elmot Landing, Arkansas, to prevent its further enlargement.

The continuous revetment required the placing of three fascine mattresses, each 267 feet wide and covering 2,605 linear feet of bank, with a stone paving along their entire length extending up the bank to about the two-thirds stage, the bank having previously been graded to a slope of 1 on 3 and dressed down to receive this paving.

The pocket at Elmot Landing had increased in length to 650 feet, and the recession of the bank line in the middle of the pocket was about 250 feet. These conditions produced a strong eddy which threatened the caving in of the revetment both above and below. To check or stop the tendency, a large spur dike was placed in the middle of the pocket. A fascine mattress 360 feet long, 100 feet wide at the shore end, and 160 feet wide at the outstream end, was first sunk as a base. On this were placed 3 cribs, as follows:

	Length.	Width.	Height.
	Feet.	*Feet.*	*Feet.*
Crib No. 1	273	24	5
Crib No. 2	260	16	4
Crib No. 3	232	8	4

These make a dike which extends into the river 253 feet, with a base of 24
crown of 8 feet, and a middle depth of 13 feet, the whole being heavily load
stone. The bank above the end of the dike and along the sides of the criba
exposed during low stages of the river, was heavily paved with stone.

(For further details, see report of Assistant Engineer Aug. J. Nolty.)

Summary of cost and of work done, extension of Fletchers Bend revetment

	Work done.	Cost per unit.	To
River mattress .... squares..	7,554.85	$5.104	$
Connecting mattress .... do....	274.21	5.308	
Grading bank .... cubic yards..	81,194	0.399	
Paving bank .... square yards..	20,481.5	.285	
Total cost	....	....	

2,605 linear feet of bank revetted; cost per linear foot..........

	Work done.	Cost per unit.	To
Elmot crib dikes .... cubic yards..	2,124.3	$1.2098	

Cost of repairs to existing works..........
Cost of surveys and examinations..........
Cost of 8,399 cubic yards stone on hand..........
Total expenditure, Fletchers Bend revetment..........

Material used, per unit.

Items.	River mat, per square.	Connecting mat, per square.	Paving, per square yard.
Brush .... cords..	1.41	1.30	....
Poles .... do....	.065	.08	....
Stone .... cubic yards..	.654	.71	.303
Wire strand .... pounds..	[a]8.63	5.40	....
Wire, annealed .... do....	[a]3.67	3.56	....
Wire, silicon bronze .... do....	.627	.20	....
Clips .... number..	1.13	....	....
Staples .... pounds..	1.85	.072	....
Spikes .... do....	....	....	....

[a] About 30 per cent of strand manufactured on works and charged as "Wire, anneale

Condition of works.—The different works along Plum Point Reach appear to
ing well, except near the head of the Daniels Point work of 1889, where
some caving, due to the extreme steepness of the bank below the zero st
appears that the strong current is letting this revetment down, either by un
ing at the outer edge, or, more probably, by scouring through the mattress,
of the old type and quite open. Caving is quite active at Mill Bayou, ab
Fletchers Bend work, and also below this work from New Haven Landing to t
of the 1895 revetment of upper Osceola Bar. Should this caving continue
it will soon cut into the chute, which was closed years ago at a large expens
ing is also continuing along the middle portion of the lower Osceola Bar, ju
the revetment of 1891. This, however, is not very rapid at present.

No boats plying the river were delayed at Plum Point Reach during the lo
of 1895.

LEVEES.

Lower St. Francis Levee district (80 to 298 miles below Cairo).—The length
district by river is 218 miles and by the levee line about 224 miles, of which 1
have been constructed. The area that will be protected by the levees wh
pleted will be 3,490 square miles.

The work done during the year consisted in the enlargement to a grade
above the high water of 1882 of the levee from Bear Bayou, Arkansas (153 R
ward for a distance of about 6 miles.

A balance of the 1896 funds being available, a contract was let to James H. C

August 24, 1896, for enlarging the levee from 153 R to 158 R, a length of 21,200 feet. This work was begun on September 9, 1896, and completed January 15, 1897. The yardage erected was 96,771, at a contract price of 8.99 cents per cubic yard.

From the river and harbor act of June 3, 1896, the sum of $16,875 was allotted to levees in this district; of this sum one-half was at once available, and the other half was to be made available by future action of Congress.

Bids for enlarging the levee from 158 R to 159¼ R, a length of 7,100 feet, was awarded to L. C. Dresbach, at 14¼ cents per cubic yard; he began work on December 5, 1896, and completed the same on February 28, 1897, erecting 47,646 cubic yards.

The credit part of the work, or that for which funds were not yet available for payment, was let to James H. Carey, and consisted of levee enlargement from about 159¼ R southward. This work was begun on February 5, 1897, and continued until March 4, 1897, when the high water overflowed the banks and caused a suspension. The work done was the enlargement of 1,900 linear feet, with a yardage of 9,824 cubic yards, at a contract price of 15 cents per cubic yard. Only 21 per cent of the contract has been completed.

There was constructed between May 1, 1896, and May 1, 1897:

	Cubic yards.
By the United States	154,241
By the local levee board	33,061
Total	187,302

The following is a summary of the levees in this district:

Constructed by the United States to May 1, 1896	2,701,171
Added from May 1, 1896, to May 1, 1897	154,241
	2,855,412
Less abandoned levees due to crevasses caused by the flood of 1897 (estimated)	53,400
Total	2,802,012
Constructed by the levee board and citizens to May 1, 1896	2,542,063
Added by the levee board and citizens from May 1, 1896, to May 1, 1897	33,061
	2,575,124
Less abandoned levees due to crevasses caused by flood of 1897 (estimated)	116,666
Total	2,458,458
Levees in place in this district on May 1, 1897:	
Erected by the United States	2,802,012
Erected by levee board and citizens	2,458,458
Total in place	5,260,470

The estimated yardage required to complete the levees to the mouth of the St. Francis River to established grades and to close the gaps made by the crevasses is 6,087,195 cubic yards.

The grades are given in detail in the report of 1896, and are in general 2 feet above the high water of 1882 at Point Pleasant, Mo. (80 R), increasing to 3 feet at 90 R, thence 3 feet to the Arkansas-Missouri State line (128 R), thence increasing to 4 feet at Barfield Mo. (142 R), thence 4 feet to Pecan Point, Arkansas (198 R), except along the west bank of Plum Point Reach, where about 430,000 cubic yards are required to raise to a 4-foot grade.

Proposed grades for extension southward from Pecan Point (198 R), are 4 feet increasing to 5 feet at Memphis, Tenn. (230 R), and from Memphis to mouth of St. Francis River (298 R), the grade to be 5 feet.

The flood of 1897 was from 1 to 3 feet higher than the flood of 1882 along the line of constructed levees in this district, and this notwithstanding the fact that crevasses occurred before the crest of the flood had passed by the levee lines. It is, therefore, estimated that the height of the St. Francis levees should be raised at least 2 feet to withstand a flood similar to that of 1897. This increase will require an estimated additional yardage of 5,500,000 cubic yards.

SECOND DISTRICT (FOOT OF ISLAND NO. 40 TO MOUTH OF WHITE RIVER, 180 MILES).

Hopefield Bend (227-230 miles below Cairo).—The revetment in this bend, now about 16,000 feet long, extends from Mound City Landing to Hopefield Point; it was begun in 1882 and completed in 1888. From 1890 to 1893 extensive repairs were made along

the lower 10,000 feet by placing wider river mats and revetting the upper ban
stone. The work along this lower 10,000 feet was failing on account of its n
width and generally weak design. Nothing but minor repairs have since been

During the late flood some damage was done near the lower end, the ex
which has not yet been determined. Any failure along this portion of th
should be speedily remedied, in order that the current may be held along th
phis Harbor front, which is yearly being encroached upon by the downstream
ment of the sand bar immediately above.

Memphis Harbor (230 miles below Cairo).—The bank for a length of 10,166
feet has been revetted by the United States, and 2,206 linear feet by a system c
built by United States employees from funds supplied by the citizens. All th
placed has held without loss, but along the upper portion of the harbor front, e
ing from Wolf River to below Monroe street, a large sand bar has formed
has made the compress, elevator, and oil mills situated above the paved leve
cessible to steamboats, and the tailing down of the sand bar along the paved ste
landing has shut off about one-half of it—or 1,500 feet—to steamboat use duri
stages of the river. At the date of the last annual report there remained an
tected portion of the bank 2,400 feet long between the lower end of the Gove
revetment and the bridge company's revetment. During the fall of 1896 about o
of this gap was closed by the construction of 1,212 linear feet of fascine matt
feet in width and the grading and paving of the bank along it. The remaini
about 1,200 feet long, should be closed as soon as funds will permit, as th
been some recent caving of the high bluff bank along this stretch. (For
details see report of Assistant Engineer William Gerig.)

Summary of cost and of work done.

	Work done.	Cost, per unit.	T
River mattress ....squares..	3,636	$5.594	$
Bank revetment................................square yards..	9,379	1.176	
Total ....linear feet..	1,212	25.89	

Material used, per unit.

Items.	River mat, per square.	Ba n
Brush ....cords..	1.27	...
Poles...do....	.054	...
Stone ....yards..	.66	
Wire strand..pounds..	9.427	...
Wire, silicon bronze, No. 9...................................do....	.89	...
Wire, No. 12, steel ....do....	5.493	...
Staples..do....	.247	...
Clips	1.292	...

1,212 linear feet grading cost $0.250 per linear foot.

Wolf River (230 miles below Cairo).—The width of the bar in front of Wolf I
low stages has increased to 2,100 feet, and through this the river has formed
fixed channel to its junction with the Mississippi. No work was done dur
last year, as the river did not get to a sufficiently low stage to prevent navi
In 1896 the lowest stage on the Memphis gauge was 1.8 feet above zero; in
was 2.4 feet below zero. The removal of obstructions in 1895 also had a
effect in giving increased depths in certain localities.

Nonconnah Rock (236 miles below Cairo).—This obstruction, consisting of a
nous sandstone and cemented gravel, is about 4 miles below the Memphis
and about 700 feet from the Tennessee shore. It has been a source of annoy
boats with heavy tows, owing to its location in the channel.

A contract for its removal was made at $2.65 per cubic yard, and the con
began work in 1893. Lacking proper plant and sufficient experience in thi
only 335 cubic yards were removed, after which the contract was cancel
January, 1896, a project was submitted and approved for the removal
obstruction by hired labor, using Government plant. A drill platform, with t
toons for floating it, was designed by Assistant Engineer W. M. Rees and
the Government fleet at Memphis. A Rand Company's Little Giant No. 4 d
used, and steam and water for jetting were supplied by a pile driver. T
platform was of sufficient size to permit the placing of 10 holes without r

the entire plant being handled from a mooring barge securely anchored in the river above.

Work was begun October 5, 1896, and closed on January 25, 1897; operations were suspended several times on account of the high stage of water; the drilling plant, as arranged, could not work in water of greater depth than 15 feet. The holes were drilled to an average depth of 4¼ feet, and charged with about 4½ pounds of 60 per cent dynamite. Five hundred and thirty-five holes were drilled; 30,350 square feet of rock was disturbed, and 2,333 cubic yards removed, at a total cost of $4,390.17, and a cost per cubic yard of $1.88. (For further details see report of Assistant Engineer Charles Levasseur.)

There are still some high points on the rock, but all below the 6-foot contour when the water surface is at zero on the Memphis gauge.

To increase the depth over the rock to 8 feet below the zero stage on Memphis gauge, which was the original project, will require an additional allotment of $2,000.

Helena Harbor (*306 miles below Cairo*).—Six hundred linear feet of continuous revetment and 5 spur dikes were built in 1889, protecting about 3,000 feet of bank along the city front. The two lower dikes being in an unfinished condition permitted bank caving along their site and below.

From the $64,000 appropriated by the river and harbor act of June 3, 1896, the following work was done:

1. From Dike No. 4 downstream there was placed a continuous revetment consisting of fascine river mats 300 feet wide, made in three sections, and the grading and paving of the adjacent bank.
2. At the lower end of the work there was built a spur dike of brush and stone having a length of 350 feet, a width of 12 feet, and a height of 6 feet; the object of this was to break up the eddy action in a large pocket at the end of the revetment, and from observations made during the last high water this work has apparently been successful.
3. Dike No. 4, which was at the head of the new work, had badly settled above the low-water line; it was built to nearly its former grade by placing on it a brush and stone crib 100 feet long, 40 feet wide, and 5 feet average height; on top of this, stone was piled to establish the former grade line.
4. Repairs were made to the upper ends of crib dikes Nos. 2 and 3 by placing stone on them to replace the decayed brush work.

One mattress 1,075 feet long broke in sinking at a distance of 430 feet from the head; the balance, 675 by 280 feet, was lost. This mat was constructed with unusual care and had many extra wire strands. The rupture was no doubt caused by the extremely swift current and by the drift which accumulated under the mat.

The revetment now in place at Helena Harbor covers a length of 4,110 linear feet; to this should be added about 1,000 linear feet to complete the work. (For further details see report of Assistant Engineer William Gerig.)

Summary of cost and of work done.

	Work done.	Cost per unit.	Total cost.
River mattress....squares..	6,563	$5.61	$36,835.03
Connecting mattress....do....	1,079	3.80	4,099.97
Bank revetment....square yards..	12,967	.868	11,244.87
New crib dike....cubic yards..	24,492	.074	1,811.32
Repairs to Dikes Nos. 2, 3, and 4....do....	12,600	.123	1,547.62
Total....linear feet..	1,610	34.49	55,538.81

Material used per unit.

Items.	River mat, per square.	Connecting mat, per square.	Bank revetment, per square yard.	Crib dike, per cubic foot.
Brush....cords..	1.25	0.947	....	0.006
Poles....do....	.059	.006	....	.001
Stone....yards..	.719	.479	0.312	.017
Wire strand *a*....pounds..	*a*12.87	....	....	....
Wire, galvanized....do....	4.30	3.7	....	.004
Wire, silicon bronze....do....	.562	....	....	....
Staples....do....	.182	....	....	....
Clips *a*....number..	*a*1.30	....	....	....

a This includes 7,000 pounds of strand and 1,600 clips made on the works.

One thousand six hundred and ten linear feet of bank graded, cost $0.428 per linear foot.

LEVEES.

Upper Yazoo Levee District (*244 to 365 miles below Cairo*).—The length of this
by river is 121 miles, and the length of levee lines 123.88 miles. The t
protected by the levees is 3,281 square miles.

At the date of my last report the work of enlarging sections 8 to 10 was
ress, and 66 per cent had been completed. John G. Sessions was the con
and he completed his work on June 29, 1896, by the addition of 39,352 cubi
the contract price being 10 cents per cubic yard.

The contract for enlarging sections 6 and 7 (249 L) was awarded to P. McC
Co. at 8.20 cents per cubic yard. Work was begun on September 1, 1896, a
pleted on February 1, 1897, the cubic yards erected being 46,991.

P. McCadden & Co. were also awarded the contract for enlarging l
sections 11 and 12 (256 L), and building along this line two loops aggregati
feet in length; the price paid was 9.20 cents per cubic yard. Work was begun
26, 1896, and completed February 1, 1897, the cubic yards erected being 145,

From the river and harbor act of June 3, 1896, the sum of $16,250 was all
this district. Of this sum one-half was immediately available for work, t
half to be made available by future action of Congress.

A contract was made with Mr. Ben Talley for the enlargement of se
(256 L) and a part of section 14, the price being 9.99 cents per cubic ya
began work on November 9, 1896, and completed the same on February
erecting 75,755 cubic yards. The credit work was awarded to Mr. Robert
at 10.99 cents per cubic yard; this included parts of sections 14 and 15
Johnson began work on January 23, 1897, and completed the same on March
erecting 71,635 cubic yards.

All the above work has a grade of 5 feet above the high water of 1882; th
is 10 feet wide, slopes on river side 1 on 3, with the same slopes on land sid
on sections 11 to 15, where the land-side slopes are 1 on 4.

	Cu
There was constructed by the United States, from May 1, 1896, to May 1, 1897	
And by the local levee board during same period	
Total	1

The following is a summary of levees in this district:

Constructed by the United States to May 1, 1896		3
Added by the United States from May 1, 1896, to May 1, 1897		
		4,
Less abandoned by constructing new lines		
Total		4,
Constructed by the local levee board to May 1, 1896		7,
Added by the local levee board May 1, 1896, to May 1, 1897		
		8,
Less abandoned by—	Cubic yards.	
Constructing new lines	27, 410	
Crevasses	93, 610	
Total		8,
Levees in place in this district May 1, 1897:		
Erected by the United States		4,
Erected by the local levee board		8,
Total in place		12,

The grades along the upper portion of this levee system for a length of 4
are 5 feet above the high water of 1882; from thence to mile section 49, in
the grades are 2 to 3½ feet above the high water of 1890. Sections 50 to 53, in
have grades of 4½ to 5 feet above the high water of 1890. Sections 54 to 5

sive, grades are 3½ to 4 feet above high water of 1890. Section 57, grades are 3 to 4 feet above high water of 1890. Sections 58 to 69, inclusive, grades are 4 feet above high water of 1890. Sections 70 to 82, inclusive, grades are generally 4 feet above the high water of 1890.

Sections 83 to 94, inclusive, of front line, sections 1 to 5, inclusive, of Ward Lake line, and sections 19 to 27, inclusive, of Hushpuckana system, have grades of 4 feet above the high water of 1893. The high waters mentioned were the highest waters along the portions enumerated prior to the flood of 1897. This flood, however, increased the high-water elevations along the lower half of the Yazoo system by from 3 to 4 feet, and showed that the levees must be built higher and have the base extended to resist successfully a flood of the proportions of that of 1897.

The estimated yardage required to enlarge levees to grades established prior to the 1897 flood was:

	Cubic yards.
Sections 44 to 57, inclusive	563,000
Enlargement below section 57; including banquets along high levees, about	1,000,000
To close crevasse at Flower Lake, sections 48, 49, made by the flood of 1897.	360,000
Total yardage required	1,923,000

The data obtained from the high water of 1897 will no doubt show that grades in this district must be raised and the levees increased in width at the base. As this data has not yet been collected and studied, it is impossible to give a precise estimate of what is required. It is probably safe to assume, however, that the levees will require an additional enlargement of at least 50,000 cubic yards per mile, or a total of 6,250,000 cubic yards.

White River Levee district (306 to 385 miles below Cairo).—The length of this district by river is 79 miles, and by the levee line, 64.4 miles. The territory to be protected is a narrow strip of from 8 to 30 miles in width, lying between the Mississippi and White rivers, and having an area of about 910 square miles.

At the date of the last Annual Report this levee was all up, but considerable of it was below established grades. A branch levee just below the city of Helena, intended as a safeguard should the front line, which was close to the river, cave in, was not yet finished. This was completed by Forrest & Co., contractors, on May 24, 1896, the amount erected during the time covered by this report being 4,717 cubic yards.

Three contracts were let during the year. The first, from funds available from the 1896 allotment, was awarded to Arnold & De Garis, for enlarging about 8 miles of levee between 336½ R and 345 R. This work was begun in September, 1896, and completed February 1, 1897, the yardage erected being 107,452 cubic yards, at 14¾ cents per cubic yard.

From the river and harbor act of June 3, 1896, the sum of $16,875 was allotted to this district, one-half being in cash and the other half to be made available by future action of Congress. Under the cash allotment a contract was made with L. C. Dresbach for the enlargement of 1,310 feet of levee at 365 R. This work was begun in November, 1896, and finished in December, 1896, the cubic yards erected being 5,293, and the price 11 cents per cubic yard.

Another contract made with L. C. Dresbach covered the enlargement of 4,600 linear feet of levee at 329 R. This was begun in November, 1896, and finished February 15, 1897, and there was erected 45,180 cubic yards, at 14½ cents per cubic yard.

Under the credit clause of the allotment a contract was made with P. McCadden for enlarging about 9,400 linear feet of levee in the vicinity of 327 R. Work was begun on this contract in January, 1897, and suspended early in March, 1897, on account of the overflow. The yardage erected was 28,800 cubic yards, or about 70 per cent of the whole contract, the price paid being 15.7 cents per cubic yard.

In addition to the above, three drainage ditches were excavated by Robert Johnsen, contractor, along the Arnold & De Garis work. The object of these was to afford an outlet to the river for the water ponded against the levee. This work was paid for out of the balance of the 1896 funds. Twelve thousand six hundred and eighty-nine cubic yards of earth was excavated, at a contract price of 12½ cents per cubic yard, and the work was completed before February 1, 1897.

There was constructed between May 1, 1896, and May 1, 1897—

	Cubic yards.
By the United States	191,442
By the local boards	105,000
Total	296,442

The following is a summary of the levees in this district:

Constructed by the United States to May 1, 1896	5, 0
Added by United States from May 1, 1896, to May 1, 1897	1
	5, 2
Less abandoned levees due to crevasses caused by flood of 1897	3
Total	4, 9
Constructed by the levee boards to May 1, 1896	9
Added by levee board from May 1, 1896, to May 1, 1897	1
	1, 0
Less abandoned levees due to crevasses caused by flood of 1897	
Total	9
Levees in place in this district on May 1, 1897:	
Erected by the United States	4, 9
Erected by the levee boards	9
Total in place	5, 8

The present levee grades are as follows: From Helena, Ark., to about 19 south, from 1¼ to 3 feet above high water of 1890; thence to 345¼ R, a length of 21 miles, is built to a grade of 4 feet, the grade line used being a practically u slope with each terminal 4 feet above the high water of 1890. From 345¼ R sout to the end of the system, a distance of about 24¼ miles, the grade is about above the high water of 1890, except for a length of about 4,600 feet near the low where the grade is but 2 feet.

Prior to the flood of 1897 the estimate for enlarging this system of levees to then established was 678,000 cubic yards. But the flood of 1897 overtopp levees along nearly the entire line and produced numerous crevasses. It is est that to close these to previously established grades will require about 975,500 yards of earthwork.

The overtopping of the levees proved conclusively that the grades were too withhold the flood of 1897, and that both grades and dimensions of levees sho increased. The estimate for this work will require at least 3,000,000 cubic y addition to the above, or a total yardage of 4,653,500 cubic yards, to comple levee system to heights and dimensions necessary to withstand a flood equal of 1897.

SURVEYS, GAUGES, AND EXAMINATIONS.

The annual low-water surveys were made of Plum Point Reach and of Me Reach and Harbor. Special surveys, including soundings, were made of New Harbor, Missouri; of caving pocket in Daniels Point revetment; along caving between Elmot, Ark., and New Haven, Ark.; of the caving pocket in front of Ark.; of the Memphis front between the work of 1894 and the bridge revetm Wolf River, Tennessee, and of Nonconnah Rock.

The revetment works constructed during the fiscal year at New Madrid Daniels Point, Arkansas, Luxora, Ark., Hopefield Bend, Arkansas, Memphis H Tennessee, Nonconnah Rock, and Helena Harbor were also located and sou taken over the work.

Discharge observations were taken during low water in the chute of Island and in the main river at Ashport, Tenn.

Examinations, including discharges, were made of Wolf and Loosahatchie and of Sycamore Slough.

Detailed surveys were made of Gold Dust Chute and Elmot Bar, and of t revetment works in Ashport and Fletchers Bend. The high-water marks of th of 1897, along the lower St. Francis Levee district, were located, and the cre measured.

PLANT.

During the year the following repairs were made:

Tug *Itasca:* New towhead and decking on forecastle, new rudder stock, an scraped and painted.

Steamer *Titan:* This boat received extensive repairs, including many new f samson post, head block, rudder blades, pitman, deck beams and deck on fore wheel and splash bulkhead. Boilers and machinery were repaired and new side put on.

Steamer *H. M. Graham:* New cylinders were placed on the boat, new wheel built, boiler foundations replaced, boilers and machinery overhauled, and rakes calked.

Steamer *H. L. Abbot:* Nothing but minor repairs were made.

Three quarter boats were docked and received extensive repairs to the hulls, especially to the sides and rakes, where the old frames and planking were replaced by new, and the boats calked. Eight quarter boats were calked on the sides and had roofs painted. One quarter boat, whose hull was beyond repair, was beached at the head of the fleet, to be used as a storeroom for property. One hydraulic grader was docked and had new foundations placed under the pumps. Two hydraulic graders had machinery overhauled, decks repaired and calked, and painted where necessary. Two machine-shop boats had guards, timber heads, and fenders renewed, and sides calked. Two mattress barges were docked and almost entirely rebuilt. Two mattress barges received minor repairs. Two mooring barges were docked, thoroughly repaired, and calked. Two mooring barges received minor repairs, but both are still in bad condition. Two old framed barges were fitted up for use as fascine barges. Three fascine barges received minor repairs. They are old and not suitable for other use. Three pile drivers were calked without docking. Thirty-seven ordinary barges, 3 fuel flats, and 3 50-foot flats were calked without docking. They are in good condition. Seven ordinary barges were docked, calked, and repaired below the light load line. A small drill platform, with two side pontoons, was built for blasting use at Nonconnah Rock. It answered the purpose well. Twenty-eight skiffs were purchased, and 3 small flats built for use during the flood of 1897. One thousand and sixty-three linear feet of discharge pipe belonging to the dredge *Alpha* was docked, scraped, and painted.

The steamer *Minnetonka*, 1 test barge, 1 quarter boat, 1 fuel flat, and 2 barges were transferred to the secretary of the Mississippi River Commission.

The cost of repairing plant is shown on a tabulated statement accompanying this report.

Sealed proposals for constructing 1 stern-wheel towboat were received at this office on February 1, 1897, and the contract awarded to Ed. J. Howard, Jeffersonville, Ind., for the sum of $25,900, this being the lowest bid. Work was begun during the latter part of March, and fair progress has been made. It is expected that the boat will be ready for launching by June 15. This boat will be 160 feet long, 30 feet wide, with 5 feet depth of hold. She will have 4 boilers, each 26 feet long, with shells 42 inches in diameter, and 5 9½-inch flues. Engine cylinders will be 18 inches in diameter and 7-foot stroke; there will be 3 steam capstans, full-sized cabin, and the boat will be double chained. Specifications and drawings for the boat were made in this office.

FLOOD OF 1897.

The water reached the danger line (40 feet) at Cairo, Ill., on February 28, and continued above it until April 27, a period of sixty days. From March 18 to April 6, a period of twenty days, it was above the 50-foot stage, the maximum stage being on March 25, when the gauge indicated 51.6 feet.

At Memphis, Tenn., the 33-foot or danger stage was reached on March 9, and the river continued above this stage until May 2, a period of fifty-five days. It was also above the 35-foot stage from March 13 to April 30, a period of forty-nine days. The maximum stage was reached on March 20, when the gauge at the upper part of the city read 37.8 feet, or 2.2 feet above the high water of 1890. This gauge was in a large eddy, just across from Hopefield Point, and the changes at the time, due to the filling and emptying of the eddy, was about 2 inches.

At the gauge of the K. C. & M. R. R. bridge, 2 miles below, the water was 1.6 feet higher than the high water of 1890. Here the conditions were more normal, as the water had a straight course from bank to bank.

At Helena, Ark., the river was above the danger line, or 40 feet, from March 8 to May 16, a period of seventy days. It was also above the 47-foot stage from March 19 to April 27, or for forty days. The maximum stage reached was on April 4, when the gauge read 51.8, or 3.7 above the highest recorded water, viz, that of 1886. The water was then rising at the rate of 0.3 feet per twenty-four hours, but the three breaks in the levees which occurred on that date—two just below Helena and one about 8 miles above and on the opposite side of the river—quickly brought relief, and the water started downward.

LOWER ST. FRANCIS LEVEE DISTRICT.

On account of the rapidly rising waters, a United States steamer, with barges, sacks, barrows, and other appliances, was sent on March 9 to protect the levees in the Lower St. Francis Levee district. This outfit was in charge of Assistant Engineer Charles Le Vasseur, who was ably assisted by Assistant Engineer A. F. Kilpatrick. The steamer was kept in this levee district until April 18, when, the water having fallen, it was withdrawn. The party rendered material assistance to the local b and citizens, by furnishing them with materials for holding the levees, and aidi organizing the forces along the district. They also guarded portions of the levees recently constructed by the United States, stopped some breaks, and rev the ends of the crevasses as they occurred, to prevent enlargement.

As the river reached stages of from 1 to 5 feet higher than any previous f along this line of levee, and as about 20 miles in the vicinity of Osceola, Ark. not yet been enlarged, much and rapid work was required to increase the heig the levees. This was in general done by the use of sacks filled with earth. long line of low and small-sized levees could not, however, be held against the rapidly rising river, and numerous breaks occurred. These are practically thi in number, three being in Missouri, and the balance in Arkansas.

The first breaks occurred near the head of Island No. 34 (177 to 179 R below C on March 14. These were caused by the water overtopping a stretch of quit levee, upon which no work had been done for about ten years. The total leng breaks here is estimated at 4,000 feet, the levee being only about 5 feet hig of small section.

At Caruthersville, Mo. (110 R), a crevasse occurred on the 18th in a levee bu the local board in 1894. This levee was supposed to be in good condition, was about 8 feet high, and the water at the time was 18 inches below the crest. Re have been made that this levee was cut, but so far no reliable information has obtained on this point. The length of the crevasse when last measured was feet. This is the only break which occurred when the water was below the ori crest of the levee.

On the 19th a break occurred about 3¼ miles below Osceola, Ark., or at 16 another break occurred on the 20th a short distance below the first, and on th a third break occurred a short distance below the second. All these breaks w a 7-foot levee, and the aggregate lengths were about 1,300 feet.

On the 21st a small break occurred in a very small levee at Craighead Point R. This is only 45 feet wide.

On the 22d a break occurred in a 7-foot levee about 2¼ miles below Osceola, 167 R. This has widened to about 820 feet.

On the 24th six breaks in all occurred, one at Lintdale, Mo. (125 R), 1,16 wide, in an 8-foot levee; one at Midway, Mo. (127 R), 1,320 feet wide, in a 1 high levee. The levee here, which was constructed by the local board in 1895 by some as yet unexplained oversight built to about 2 feet below the establ grade, and this without the knowledge of this office. The third break occ about three-fourths of a mile below Osceola (165 R), was 300 feet wide, in a about 7 feet high, and the fourth, fifth, and sixth, at Pettys Landing (167¼ R all close together, and have an aggregate length of about 1,400 feet, in a levee 7 feet high.

All the breaks above enumerated had the effect of materially lowering the in the river proper and filling the St. Francis bottom opposite and above Memp about its maximum flood height.

No further breaks occurred after March 24. The unbroken levees protecte farming lands back of them from Point Pleasant, Mo. (80 R), to Caruthersville (110 R); also the lands near to and back of the levees between Barfield, Ark. (14 and Osceola, Ark. (164 R), and about 3 miles of front lands in the vicinity of Point, about 195 R. Below this there are no levees, and the country was all overflowed to a depth of from 2 to 3 feet greater than ever before. Prior t flood, that of 1882 was the highest ever recorded. Elevations taken along the l are as follows:

At Point Pleasant, Mo. (80 R), 0.49 feet below the flood of 1882.

Elevations above the flood of 1882 were:

Gayoso, Mo. (106 R)
Caruthersville, Mo. (110 R)
Cottonwood Point, Mo. (123¼ R)
Lintdale, Mo. (125 R)
Midway, Mo. (127 R)
Barfield, Ark. (142 R)
Luxora, Ark. (161 R)
Osceola, Ark. (165 R)
Craighead Point (170 R)
Fulton, Tenn. (175¼ R)
Pecan Point, Ark. (195 R)

The elevations are the maxima obtained, and occurred before the crest o flood had passed. It is probable that they would have been exceeded if the l had not broken, but by what additions it is difficult to say. The river, howev

Cairo rose 1½ feet after the Caruthersville break occurred, and it is probable that the flood line along these levees would have been increased to about that extent if the levees had held.

At Walnut Bend, Arkansas (280 R), there were 6 miles of levee, built in 1894 to prevent a cut-off into St. Francis River. This levee was built to a grade of 2 feet above the high water of 1882, but the high water of 1897 reached practically to its top, running over it in numerous places. We can assume, therefore, that the flood of 1897 was 2 feet higher than that of 1882 in this vicinity. All the farms below Walnut Bend and between Walnut Bend and Memphis were more deeply inundated than by any previous flood, as shown by the fact that most of the inhabitants were obliged to vacate houses which during other floods they occupied.

Of the 3,490 square miles in the district all but 895 square miles were inundated.

The cost to the Government of protection works in this district was $6,782.08.

The river along this district has receded within its banks, and most of the farmers are busily engaged in planting.

WHITE RIVER LEVEE DISTRICT.

On March 10 and 11, when the Helena gauge was 42 feet, the water had overflowed the bank and was against the levee in nearly all places. Mr. C. H. Purvis, assistant engineer in charge of this district, then made an examination of the levees, and found that at Station 1214, Helena (331 R), and at Station 930, Laconia (364½ R), the water was within 4 feet of the crest, and that at intermediate points the water was, in general, about 6 feet below the crest, except in the vicinity of Station 1300, Laconia (345½ R), and near Station 1500, Laconia, where the water was from 8 to 9 feet below. Between Station 900, Laconia (365 R) and O. (385 R) the water was not up to the danger line. Work was at once begun to raise the levee at Station 930, Laconia, and at other low places, teams and scrapers being used for the purpose. The river rising rapidly at Helena, means were at once devised to guard and protect the levees in this district. The Cotton Belt Levee district at Helena agreed to take charge of the levees between that place and Westover, a distance of about 12 miles. Along this portion there was much low levee, and the local board was obliged to raise the line with sacks filled with earth for nearly the entire portion and for some distance below. This work was done under good management and by the liberal expenditure of funds.

On March 12 the steamer *Titan*, with barges and material, was sent to this district. Assistant Engineer A. J. Nolty was placed in general charge, with Assistant Engineer C. H. Purvis in local charge of the upper portion, Assistant Engineer M. Gardner in local charge of the middle portion, and Assistant Engineer Fred Wigstrand in local charge of the lower or Laconia portion. In addition to steamer *Titan*, two small steamers were employed to assist her in distributing supplies and moving laborers from place to place, where their services were most needed. One quarter boat was used for quartering laborers along sparsely settled portions of the line. Numerous barges were in use, both for handling material and, later, for affording rescue stations for the people and their stock after the levees had broken.

Nearly all of the work done was in raising the crest with earth-filled sacks to prevent overflow, although several badly seeping places were treated near the base of the inside slope to guard against failure by sloughing. Notwithstanding all the work done, the river rose so rapidly that it went over the top of the levees and produced numerous breaks. On March 18 the water was running over almost the entire line between Oldtown (325 R) and Hugheys (337 R), a length of levee of about 11 miles. This portion was then abandoned.

There are in all 14 crevasses in this district. Most of them are in large levees, and a very recent survey shows an aggregate width of breaks of 16,420 feet and a yardage loss of 344,500 cubic yards.

A very rapid current passed through many of the breaks, scouring deep holes on the land side. This will necessitate the construction of long loops to close many of the breaks, the aggregate length of which is about 31,000 linear feet, requiring the erection of about 975,000 cubic yards to close the entire line up to the prior established grades.

A general description of the breaks is as follows:

CREVASSES.

Modoc No. 1 (336 R), broke March 22; width, 1,315 feet; height of levee, 13 feet; overtopped.

Modoc No. 2 (337 R), broke March 23; width, 750 feet; height of levee, 15 feet; overtopped.

Hugheys (337½ R), three breaks with but little levee between them; aggregate width, 1,460 feet; height of levee, 12 feet. Two of the small breaks occurred March

23 by overtopping; the levee was cut by direction of the Laconia levee boa object being to make the crevasse wider, to draw off the water into the White basin and thereby prevent breaks in the levees above the Laconia Circle.

Dixie's (340 R), cut by direction of the Laconia levee board on March 23; 750 feet; height of levee, 12 feet.

Schoolhouse Bayou (342 R), cut by direction of the Laconia levee board Ma width, 3,140 feet; height of levee, 12 feet.

Ferguson's (364 R), broke March 25; width, 1,340 feet; height of levee, 1 overtopped.

Wood Cottage No. 1 (365 R), broke March 27; width, 1,425 feet; height of 10 feet; overtopped.

Wood Cottage No. 2 (365 R), broke March 29; width, 1,530 feet; height of 10 feet; overtopped.

Henrico No. 1 (384 R), broke March 30; width, 265 feet; height of levee, 1 overtopped by the inside water in Laconia Circle.

Henrico No. 2 (384 R), broke March 30; width, 870 feet; height of levee, 1 overtopped by the inside water; also reported to have been cut to let water circle.

Huntington (385 R), broke March 30; width, 340 feet; height of levee, 1 overtopped from inside.

Westover (321 R), broke April 1; width, 800 feet; height of levee, 16 feet; caused by faulty construction, logs having been placed in the center.

Williamson's (309 R), broke April 4; width, 1,400 feet; height of levee, 1 break caused by swift current on outside, which cut away the river slope. one of the most disastrous breaks in the system.

Hubbart's (311 R), broke April 4; width, 1,140 feet; height of levee, 10 feet. caused by quicksand foundation, producing sloughing at inside of base.

After these breaks the river fell rapidly along the entire front. Work w tinued for a short time along the unbroken portions to prevent further cre and some work was done to prevent further enlargement of certain crevas at Williamson's, Schoolhouse Bayou, and Wood Cottage No. 2. All this work revetment of lower ends, and it proved successful.

At Williamson's crevasse a very rapid current was moving along the inside levee and scouring the back slope, especially at the big Long Lake Levee, 2,000 feet below. To save this from breaking, spur dikes of sacks were plac the current deflected from the inside base of the levee.

On April 16 all work was suspended except the removal of plant, which was at once.

The flood of 1890 was the highest previously recorded along the upper part district, but the flood of 1893 slightly exceeded it along the lower portio entirely to the contraction caused by extension of the levees. The forme elevations, viz, 1890, were therefore used in establishing the levee grades.

The flood of 1897 exceeded the flood of 1890 along the entire line, as in below:

Above the high water of 1890:
  At Williamson's (309 R)..
  Westover Landing (319 R)......................................
  Oldtown Landing (325 R)..
  Modoc Landing (335 R)..
  Hugheys Landing (337 R)..
  Schoolhouse Bayou (342 R)......................................
  Wood Cottage (365 R)...
  Laconia (374 R)..
  Henrico (384 R)..

The cost to the Government of protection work in this district was $26,223.

The water on May 18 had not receded sufficiently to allow planting to beg it is thought that this will commence within a few days.

Of the 910 square miles to be protected by levees in this district, nearly al flooded, only about 2,000 acres along Oldtown ridge being above the overflow

UPPER YAZOO LEVEE DISTRICT.

No protection work was done on the levees in this district, as the chief engi the local board agreed to do this work; but near the close of the flood the funds local board having become exhausted, the Government assisted them to the ex paying for the labor of protection in the upper end of the district. The local made a vigorous fight along nearly the entire line, and were compelled to raise miles of levee, both by the use of earth in sacks and by plank revetment backed up with earth.

Only one break occurred in the main line; this was on April 4, at Flower Lake (300 L). The water at the time was above the crest, which had been topped by sacks to prevent overflow. The levee being high—about 16 feet—it became almost thoroughly saturated at the base, and failed by sudden sloughing along the inside slope. The crevasse increased in width quickly, and when the caving ends were finally checked by the revetment the width had increased to 2,025 feet. A vast volume of water poured through this crevasse for a long time, but when the water fell sufficiently a temporary dike of piling, sacks, and earth about 2,600 feet long was built around it on the river side, and the discharge has been practically stopped.

The overflow from this crevasse affected Tunica, Coahoma, and Tallahatchie counties, inundating 342 square miles.

The assistance rendered by the Government was $3,540.85 for the pay of laborers and the loan of 3 large quarter-boats for high-water employees.

The following are the elevations of the flood of 1897 above previous high waters:

	Feet.
Above high water of 1882:	
Lake View (245 L)	0.55
Nehms (247 L)	.40
Norfolk (254 L)	.44
Star Landing (257 L)	.18
Holloways (259 L)	.45
Clacks (263 L)	.10
Indian Creek (265 L)	.70
Commerce (268 L)	.50
Walter Johnson's (274 L)	2.20
South end Moon Lake (278 L)	3.45
Sanders' (285 L)	2.65
McKinneys Bayou (287 L)	3.37
Austin (289 L)	3.45
Above high water of 1890:	
Kyles (292 L)	4.25
Above high water of 1886:	
Willow Slough (304 L)	3.60
Above high water of 1886, 1890, and 1893:	
Glendale (306 L)	3.35
Above high water of 1893:	
Mays (313 L)	3.60
Friars Point (319 L)	3.35
Stovall (326 L)	4.20
Hensleys (332 L)	4.75
Burke's (334 L)	3.95
Hushpuckana, Sunflower (353 L)	4.20
Above high water of 1890:	
Malones Landing (356 L)	4.55
Pushmataha (360 L)	4

MEMPHIS AND VICINITY.

The unprecedented flood in the vicinity caused great distress, overflowing places never heretofore inundated.

The tug *Itasca*, in charge of Overseer Louis Haas, was employed from March 14 to 25 in rescuing the people and their stock. The scenes of these operations were: Island No. 40 and the Arkansas shore opposite, Presidents Island and its vicinity.

The *Itasca* brought to Memphis 177 persons, 95 horses and mules, 173 head of cattle, 82 hogs, and a large lot of personal effects and household goods.

One trip was made by the survey boat *Abbot* to the Arkansas shore above Island No. 40; 63 people were brought to Memphis from the overflowed territory there.

The *Itasca* also placed seven barges along the river at different points, as quarters for the flood refugees, until such time as they could embark on passing steamers. Numerous skiffs were also furnished to responsible people, and to the Memphis relief committee, to transport people living back of the river to the barges or other places of safety.

It is desired in this connection to place on record the very willing and efficient manner in which the assistants connected with this office performed the arduous duties allotted to them during the flood period. Assistant Engineer Nolty, who was in charge of the *Titan;* Assistant Engineer LeVasseur, who was in charge of the *Graham*, and Overseer Haas, who was in charge of the *Itasca*, deserve special mention; also Assistant Engineer Rees, who rendered able assistance at Memphis.

The overflow of 1897 compared with previous overflows since 1882.

[Length of crevasses determined by careful measurements made,between May 1 and 18, 1

LOWER ST. FRANCIS LEVEE DISTRICT.

[224 miles long.]

Year.	Overflowed area.	Length of crevasses.	Total length of levee line built.	Remarks.
	Sq. miles.	*Feet.*	*Miles.*	
1882	3,308	....	(*a*)	This district was not prote levees until after the high 1893. Between 1893 and 1 miles of levees was built; miles of this 115 miles wa the established grade.
1883	3,308	....	(*a*)	
1884	3,308	....	(*a*)	
1886	3,308	....	(*a*)	
1890	3,308	....	(*a*)	
1891	*b* 3,000	....	(*a*)	
1892	3,308	....	(*a*)	
1893	3,308	....	(*a*)	
1897	2,595	13,405	115	

a No levee. *b* About.

WHITE RIVER LEVEE DISTRICT.

[64.4 miles long.]

Year.	Overflowed area.	Length of crevasses.	Total length of levee line built.	Remarks.
1882	*a* 900	*a* 10,000	*a* 20	Built to low grade.
1883	*a* 900	*a* 10,000	*a* 20	Do.
1884	*a* 850	*a* 1,000	*a* 22	Do.
1886	*a* 500	None.	*a* 30	Built to higher grade.
1890	*a* 600	*a* 3,000	*a* 30	
1891	*a* 500	None.	37	
1892	*a* 400	None.	41	
1893	*a* 400	None.	46	
1897	*a* 900	16,420	64.4	

a About.

UPPER YAZOO LEVEE DISTRICT.

[124 miles long.]

Year.	Overflowed area.	Length of crevasses.	Total length of levee line built.	Remarks.
1882	3,281	37,000	(*a*)	Old low levee.
1883	3,281	37,000	(*a*)	Do.
1884	3,281	37,000	(*a*)	Do.
1886	98	(*b*)	*c* 124	Old crevasses had been clo levee enlarged.
1890	50	(*d*)	124	Levees were strengthened e from 1884 to 1897 by raisin and enlarging cross section the flood of 1897 occurred erable portion of the line below grade, 1 to 3 feet.
1891	17	(*e*)	124	
1892	None ...	None ...	124	
1893	None ...	None ...	124	
1897	342	(*f*)	124	This broke at a low place in l

a About 117 miles up to low grade.
b 3 crevasses, about 3,000 feet.
c About.
d 1 crevasse, about 500 feet.
e 1 crevasse, about 6
f 1 crevasse, 2,025 fe

Very respectfully, your obedient servant,

GRAHAM D. FITCH
Captain, Corps of Engi

Col. G. L. GILLESPIE,
President Mississippi River Commission.

Cost of care of and repairs to plant from May 1, 1896, to May 1, 1897.

Steamer *Minnetonka*	$56.33	Barge No. 9313	$61.65
Steamer *Titan*	3,536.78	Barge No. 9314	105.75
Steamer *Graham*	896.31	Barge No. 9315	27.50
Steamer *Itasca*	353.40	Barge No. 9316	31.95
Steamer *Abbot*	29.39	Barge No. 9317	40.75
Pile driver No. 19	20.45	Barge No. 9319	57.36
Pile driver No. 20	35.55	Barge No. 9320	36.25
Pile driver No. 61	11.31	Barge No. 9321	79.90
Quarter boat No. 11	90.48	Barge No. 9322	33.40
Quarter boat No. 12	19.71	Barge No. 9323	74.70
Quarter boat No. 27	785.92	Barge No. 9325	35.37
Quarter boat No. 39	629.89	Barge No. 9326	35.25
Quarter boat No. 206	1,478.84	Barge No. 9327	44.75
Quarter boat No. 221	1,563.60	Barge No. 9328	83.01
Barges Nos. 74, 76, and 94	129.49	Barge No. 9329	21.37
Barge No. 202	98.26	Barge No. 9407	45.67
Barge No. 203	213.98	Mooring barge No. 1	327.02
Barge No. 206	96.40	Mooring barge No. 2	366.76
Barge No. 208	8.40	Mattress barges Nos. 3 and 4	1,916.44
Barge No. 209	189.20	Mattress barge No. 5	93.70
Barge No. 211	143.97	Mattress barge No. 6	93.72
Barge No. 213	147.60	Hydraulic grader No. 2	1,517.80
Barge No. 215	116.10	Hydraulic grader No. 4	407.26
Barge No. 218	121.75	Hydraulic grader No. 40	127.31
Barge No. 223	107.22	Skiffs	40.65
Barge No. 227	116.60	Tools and appliances	654.86
Barge No. 228	98.45	General repairs	1,719.93
Barge No. 229	98.89	Towing	2,960.25
Barge No. 9301	46.09	Care of plant	12,285.62
Barge No. 9302	68.10	Machine boat No. 1	49.35
Barge No. 9303	26.87	Machine boat No. 2	28.91
Barge No. 9304	93.55	Barge No. 161	196.57
Barge No. 9305	112.26	Drill platform	220.64
Barge No. 9306	72.60		
Barge No. 9307	81.00	Total	35,343.98
Barge No. 9310	27.92		

Respectfully submitted.

AUG. J. NOLTY, *Assistant Engineer.*

REPORT OF MR. AUG. J. NOLTY, ASSISTANT ENGINEER, ON OPERATIONS OF CONSTRUCTION PARTIES AT PLUMPOINT REACH AND NEW MADRID.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., April 20, 1897.

CAPTAIN: I have the honor to submit my annual report of operations at Plumpoint Reach and at New Madrid, Mo., for the season 1896-97.

Storage of stone.—Bids for furnishing stone and quarry spalls for the contemplated work on Plumpoint Reach were opened June 1, 1896, and contract awarded to Edmund Ligon & Co. at 46 cents per cubic yard for both riprap and spalls, delivered on United States barges at contractors' quarry, towing to be done by the United States steamers.

Under this contract there were delivered by September 24, 16,847.9 cubic yards of riprap and 2,632.5 cubic yards of spalls, making a total of 19,480.4 cubic yards, costing, delivered on barges, $8,960.98.

On the 14th of June the steamer *Minnetonka* was placed in commission, leaving on the following day with a tow of 12 barges destined for the quarries at Grand Tower, Ill. On the 22d 12 more barges were taken to the quarries by the same boat. On July 5 this boat was turned over to the secretary of the Mississippi River Commission, and it was replaced in the stone-towing service by the steamer *Titan*, repairs to which boat had just been completed.

The first tow of stone was received at Fletchers Bend, where the storage depot had been located, on July 5, and the work of storing it on the bank was at once begun by a previously organized force of self-subsisting laborers under charge of Overseer C. W. Fink; 13,501 cubic yards was stored on the bank and 5,979.4 cubic yards was held on barges to be subsequently used direct on the work.

Of the total amount stored on the bank, 5,102.1 cubic yards was reloade barges for consumption on the work. There remained on hand, stored on th at Fletchers Bend, at the close of the season's work, 8,399 cubic yards, of about 600 cubic yards is spalls.

The total cost of towing and handling (unloading and reloading) ston follows:

Towing 19,480.4 cubic yards	$6,
Unloading 13,501 cubic yards	1,
Reloading 5,102.1 cubic yards	1,

Or, taking the above by units—

Towage, per cubic yard	
Unloading, per cubic yard	
Reloading, per cubic yard	

Taking the cost of the 5,979.4 cubic yards not unloaded, and to the contrac of which only the expense of towing is to be added, and adding to this the 5,102.1 yards unloaded from and reloaded upon barges, the cost per cubic stone ready to be placed upon the work is $1.302, as follows:

Contract price per cubic yard	
Towage price per cubic yard	
Handling 5,102.1 cubic yards, per cubic yard	

The 8,399 cubic yards of stone still on the bank at Fletchers Bend represent value of $8,407.40.

Of the above quantity of stone on hand 4,500 cubic yards were intended extension of the New Madrid revetment, but by the time this stone was r leave the quarries it had not yet been definitely decided whether or not thi should be undertaken this season; hence the stone was ordered down to Fl Bend. When the New Madrid work was finally undertaken it was found to b economical to purchase the required stone by contract rather than tow it up a distance of 90 miles.

As usual, the cost of towage was considerably increased toward the close prevalence of low water between Cairo and the quarries, necessitating no reduced draft of the barges, but also double tripping to Cairo.

One steamer, the *Joy Patton*, was chartered for a short time to assist in getti the last of the stone. The steamers engaged in this service and the length of employed, are as follows:

U. S. S. *Minnetonka*	
U. S. S. *Titan*	
Chartered steamer *Joy Patton*	

All labor employed in handling stone up to September 16 was self-subsistin borers were paid $1.20 per day. Higher-grade employees were allowed an i in their pay of from $7.50 to $15 to reimburse them for subsistence paid by th

As the river at the time of unloading was quite high, a great deal of the sto simply dumped off barges; hence the difference between the cost of unloadi reloading. In the latter case of course all stone had to be wheeled onto the

Extension of Fletchers Bend revetment.—The original project for this extensi templated 2,000 linear feet of standard revetment, to begin at a point as close brush and stone crib placed below the foot of Section E in the previous would give a lap over the foot mat of that crib. The head of the new work as placed is situate 325 feet below the then foot of Section E, running thence d front of the town of Luxora, Ark., and beyond.

The construction of a brush and stone crib in the middle of the deep pocket b the foot of Section D and head of Section E, for the purpose of breaking up the eddy prevailing there, was also included in the project.

For more than ten years prior to 1895 no caving had taken place along th which was now to be revetted; but early in 1895 caving began at the foot of E, and in a very short time about 2,000 feet of the bank was involved, th ing not only the destruction of large areas of valuable town land and necess the removal farther inland of all buildings fronting the river, but the lar costly United States levee was menaced. The effects of this unchecked cavi also beginning to affect the hitherto good depths of the crossing from New H Island No. 30, for the recession of the bank allowed a large volume of water down by the Arkansas shore, not only robbing the crossing of that much wat also by acceleration of the current causing heavy erosion along the sandy b upper Osceola Bar. So long as the Luxora bank held, the current was de away from this bar, and very little caving had taken place since Osceola Ch been closed in 1885. The caving along the bank of this bar becomes more significant when it is remembered that the width of it is quite small, being not more than 300 feet across at one of the exposed places, and cutting through here would mean the reopening of Osceola Chute, closed at a large expense in previous years.

The closure works placed in this chute during the years 1882–1885, while having entirely accomplished their purpose, are practically destroyed from age, and would offer but slight resistance to any considerable increment of water passing through.

Subsequent to the beginning of operations, the originally contemplated revetment of 2,000 feet was increased to 2,600 feet, as it was found that the caving extended down that distance.

Before commencing operations the owners of river-front property were communicated with for cession of land required for the work and for removal of all fences and buildings within the zone required for the revetment, all this to be done without expense to the United States, all of which was willingly acceded to by the parties in interest.

Preliminary work, such as getting out piling for the abutments, hardwood heading poles for the mattresses, and driving abutment for mat No. 1, was begun on September 16 by the stone storage party.

Active operations were begun September 24, upon which day river mat No. 1 was begun. This mat was constructed along the most actively caving part of the bank, and caving continued until the mat was sunk. One cave-in on top of the floating mat was so serious as to destroy a large part of the finished mat. This damage was subsequently repaired by building an extra layer of mat over the damaged part, care being taken to restore all the wire-strand fastenings, so that the strength of the whole structure was unimpaired. A second cave-in at another place again damaged the mat, though not to the same extent as the first one, and a third and very large cave-in was only averted by hastily removing the large block of bank as far back as the fissure, and more than halfway down vertically. As soon as the mat was sunk, which was on October 9, all caving ceased. Mat No. 1 is 887 feet long and 267 feet wide.

Mat No. 2, lying above No. 1, was begun October 12 and sunk on the 30th of the same month, after attaining a length of 1,313 feet. Its width is 267 feet.

Mat No. 3, lying below No. 1, was begun on December 12, after the mat outfit had returned from New Madrid, whither it had been sent after the completion of the Elmot Crib, as the matter of a further extension of the Fletchers Bend revetment had not yet been decided. This mat was sunk on December 22. Its length is 455 feet and width 267 feet.

These three mats cover a length of bank of 2,605 feet, 50 feet of the aggregate length being used for overlap of No. 2 over No. 1, and No. 3 over No. 1.

No difficulties were encountered in either construction or sinking of the mattresses, although at the time that mat No. 3 was under construction the river was at a 10-foot stage, with a very strong current and much heavy drift running.

Connecting mats.—Of these, four were required to cover deep indentations or pockets into which it was impracticable to work the main mats. The four averaged 190 squares. One of these had to be built quite high up the graded bank, as the part of the slope covered by it was composed of material so saturated with seep water as to make it too soft to receive the riprap without this foundation of brush. Considerable seep water flowed out here, the source of which is evidently the near-by deep borrow pits, which are nearly always full of water.

Grading.—Prior to beginning construction of mat No. 2 it was found necessary to grade down the foot of the bluff bank for a sufficient distance back to obtain a secure resting place for the shore edge of the mat. The length of bank so treated was 1,250 feet, with a width—measured from the wet contour up—of 11 feet. This work was done with a pile-driver pump.

Regular grading of the bank was begun October 10, one day after the first mat was sunk. A second grader began work on the 15th of the same month. These two machines worked until October 26, when they were temporarily laid up, to resume work on October 31, the day after mat No. 2 was sunk. On November 10, grading in front of the sunken mats having been completed, both graders were laid up for the present. In front of the town proper the grade was carried to the top of the bank. At other places the usual 8-foot bluff was left standing, which brings the grade to about the 23-foot contour.

On December 23, river mat No. 3 having been sunk the day previous, grading was resumed with one machine, completing this part of the work on the 28th. Of the 430 feet of bank in front of this mat, 175 feet had been graded previously, leaving, therefore, only 255 feet to be graded after the mat was sunk.

Paving.—This was laid in the usual manner on a 4-inch foundation of quarry spalls, and was started 8 inches thick, exclusive of the spalls, at the foot of the slope, diminishing to 6 inches at the top. Paving was carried up to the 22-foot contour (Amelia gauge).

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] steamers engaged in this service and the [illegible] employed are as follows:

[illegible]

[illegible]

Chartered steamer [illegible]

All [illegible] employed in handling stone up to September 30 [illegible] were paid [illegible] per day. [illegible] employees were allowed [illegible] to reimburse them for subsistence paid [illegible]

[illegible] the time of unloading was quite high a great deal of th[illegible] dumped off barges; hence the difference between the cost of un[illegible] of course all stone had to be wheeled [illegible]

[illegible] revetment.—The original project for this ex[illegible] ard revetment, to begin at a point ne[illegible] the [illegible] of Section E in the previ[illegible] The head of the new w[illegible] of Section E, running the[illegible] d.

[illegible] the middle of the deep poo[illegible] or the purpose of breaking [illegible] the project.

[illegible] caving had taken place alo[illegible] n 1895 caving began at the fo[illegible] feet of the bank was invol[illegible] of valuable town land [illegible] ngs fronting the river, [illegible] The effects of this un[illegible] depths of the crossin[illegible] nk allowed a large [illegible] obbing the crossing [illegible] ing heavy erosion [illegible] uxora bank held [illegible] ing had taken [illegible]

in 1885. The caving [illegible]
emembered that the [illegible]
at one of the exposed [illegible]
of Osceola Chute, closed at a [illegible]
re works placed in this [illegible]
ccomplished their purpose [illegible]
ight resistance to any [illegible]
nt to the beginning of [illegible]
t was increased to 2,6[illegible]
distance.
mmencing operations the [illegible]
for cession of land [illegible]
gs within the zone [illegible]
to the United States [illegible]
terest.
y work, such as getting [illegible]
r the mattresses, and [illegible]
6 by the stone [illegible]
rations were begun [illegible]
mat was constructed [illegible]
ntinued until the [illegible]
rious as to destroy a large [illegible]
repaired by building [illegible]
en to restore all [illegible]
cture was unimpaired. [illegible]
though not to the same [illegible]
was only averted by [illegible]
fissure, and more [illegible]
hich was on October [illegible]
e.
, lying above No. 1 was [illegible] r
, after attaining a length [illegible] of
, lying below No. 1 was [illegible]
m New Madrid, whither [illegible] ad,
as the matter of a further [illegible] are
been decided. This [illegible] out-
lth 267 feet. [illegible] full
ee mats cover a length of [illegible] ll the
used for overlap of No. [illegible] arges.
ties were encountered [illegible] by the
the time that mat No. [illegible] dragged
a very strong current [illegible] ed.
mats.—Of these four [illegible] ably forms
which it was impracticable [illegible] is is 35 feet
One of these had [illegible]
slope covered by it [illegible] ith the larger
make it too soft [illegible] the meantime
seep water flowed [illegible] Headquarters
borrow pits, which [illegible] rge could person-
Prior to beginning [illegible] n promised to give
he foot of the [illegible] l three jets, but the
or the [illegible] much water. Two of
idth [illegible] ne jet was used, with
[illegible] of the slope had to be
[illegible] feet of bank at the head
[illegible] grader, being afterwards
[illegible] ember 17 and headquarters
[illegible] aterials Prewitt being left
[illegible] done in the usual manner and
[illegible] ch is at about the 33-foot stage.
[illegible] onto United States barges of
[illegible] on December 31, when the force
[illegible] xora.
[illegible] some damage from rain wash may
[illegible] e as a complete submergence by the
[illegible] rap.
[illegible] as sleeping accommodations in town
[illegible] rce were allowed to sleep on the large
[illegible] llar and twenty cents per day was paid

The day following the sinking of mat No. 3 the mat plant, together with
the force, was sent to Daniels Point for work there. A small force was left at L
to complete the paving and to load stone for the Daniels Point work. All wor
completed at this place on January 12 of the current year. About 20 cubic ya
stone was left on the bank to be used by the citizens in repairing any fault
paving that might result from surface drainage. Two small washouts in the p
were repaired the day prior to breaking camp. The citizens have promised
all in their power to prevent or quickly repair any damage that the work migh
tain from surface water. They have since constructed a small levee to preve
surface water from running down the slope.

On January 20 field headquarters were moved to Memphis, all work except t
Daniels Point having been completed. The latter was finished one week late
All brush and poles for this and other work on Plum Point Reach were fur
by Messrs. Hunter & Frey at $1.04 per cord for brush and $1.60 for poles, del
on United States barges at contractors' camp. For every one-quarter of a m
fraction thereof, beyond 1 mile haul, 7½ cents per cord extra to be paid. All m
of the contractors' outfit to be done by the United States. The territory from
they were allowed to obtain brush and poles was limited to between Cai
Memphis.

Crib dike, Elmot Landing.—The site of this work is in the center of the deep in
tion between the foot of Section D and head of Section E of the interrupted reve
of part of Fletchers Bend. The distance between the ends of these two sections,
had originally been 500 feet, had, prior to the construction of the stone
designed by Lieutenant-Colonel Stickney, Corps of Engineers, United States
increased to 650 feet, while the recession of the bank line in the deepest part
pocket amounts to 250 feet. The strong eddy, which was the natural seque
such a feature in the bank, was continually doing more damage, and threate
involve the protected ends of the sections, besides endangering the United
levee, which here is very close to the bank.

It was therefore necessary to place some structure to break up this eddy, a
this purpose a 3-tier brush and stone crib, founded upon a fascine mat of
size, was designed.

The construction of the mat was begun on November 1 and completed on t
Its width, normal to the bank, is 360 feet, while its length varies from 100
the shore end to 160 feet at the outstream one, the upstream edge making a
angle with the two ends and the general bank line. Owing to nonavailabi
sufficient plant to make this mat in the usual manner, i. e., fascines normal
bank, it was made with fascines longitudinal.

The first or lowermost crib was built 273 feet long, 20 feet of its length ly
the bank inside the zero contour, and in a trench excavated for it. Its width
feet and thickness 5 feet.

Crib No. 2, resting on top of No. 1, is 260 feet long, 16 feet wide, and 4 feet
It leaves 30 feet of the outer end of No. 1 uncovered, and projects 37 feet insi
low-water line.

Crib No. 3, resting on No. 2, is 232 feet long, 8 feet wide, and 2 feet thick a
end, increasing to 4 feet at outer end. It projects 39 feet inside the zero c
and leaves 30 feet of No. 2 exposed.

From the shore edge of the mat up the bank was graded for 100 feet an
properly paved, an extra quantity of stone being piled around the ends and a
the sides of the different cribs to prevent cutting and undermining. The
extends up to the 20-foot stage. All work, except a little paving, was comple
November 21, and the deferred paving was completed January 5.

As soon as the last crib was sunk the mat outfit, together with the bulk
working force, was sent to New Madrid.

All white labor employed on the works at Plum Point were subsisted on
States quarter boats. Colored labor was self-subsisting. Ninety cents per
eight hours was paid the former and $1.20 to the latter class.

Since the construction of the stone groins around the ends of the secti
detached revetments in Fletchers Bend no caving off of these ends appears t
taken place.

The cost of towing brush and poles for Plum Point work was $0.33+ per co

Extension of revetment, New Madrid front.—Sixteen hundred feet of revetme
been constructed along the upper front of this town, and the project for thi
provided for an extension downstream as far as the funds available would
Only $14,500 being allotted for the field cost of this work, an extension of 5
was all that it was deemed advisable to undertake, in order not to exceed the
amount.

Five hundred feet of revetment would require 520 feet of mat, 20 feet
allowed for overlap on the work put in in preceding years. The origina
gramme had been to do the work here in the early part of the working seaso

it was therefore decided to unload the last 4,500 cubic yards of stone furnished by contractors Ligon & Co. at this place. However, by the time that the first tow of this lot was ready to leave the quarries the order of work was changed, as it had not been definitely decided whether or not the New Madrid work would be done this season. Hence it became necessary to order the stone to the general depot at Plum Point. When it was finally decided to begin the extension here, the 3,500 cubic yards required were obtained under a new contract made with John Barret & Son, this being considered fully as cheap as towing stone from Plum Point, even if barges and towboats were available for this purpose, which, however, they were not.

The cost of stone and spalls was $1.30 per cubic yard, delivered at the work, with no charge for detention of barges.

Plant for this work was towed from Plum Point November 12–25. Piling for the abutment, hard-wood heading poles for the mat and logs for the mattress anchorages were gotten out at Fletchers Bend, there being no suitable timber within easy reach of this work. All the mooring lines had to be fastened to "dead men," as the bank was entirely denuded of timber. After completing the preliminary work, such as clearing the bank, driving abutment, and placing the anchorages, actual construction of mattress began on November 27. The river, which stood at 8.5 feet, New Madrid gauge, began rising the same day and continued rising until the day the mat was sunk, when it registered 19 feet, New Madrid gauge. Large quantities of heavy drift, among which was a raft of 115 saw logs, lodged in front of the mooring barges, but as the drift chains were early put out, very little drift worked under the mat. The mat, which was 267 feet wide, was sunk on the 8th of December, rain preventing its earlier sinking, although it was ready for this final operation on the 5th.

Considerable anxiety as to how this mat would behave during the process of sinking was induced by the immense accumulation of drift and the strong current, but the mat went down in the very best of shape. As the river was quite high during construction, the mat lies higher up the bank than is desirable, but of course this could not be avoided. However, the strip of mat that will be exposed during a low stage of river has been as near as was possible heavily covered with riprap, in order to minimize the injurious effects of alternate exposure to atmosphere and water of the brush. Maximum depth of water where mat was sunk was 72 feet below zero.

The day following the sinking the mooring barges were carefully swung around, in order to allow the accumulated drift to float off, and although the utmost care was taken to swing them around gently, and having the *Titan* lashed to the outstream end of the mooring plant pushing against the current with engines at full stroke, the force of the mass of drift when once in motion was iresistible and all the lines had to be thrown off in order to prevent the wrecking of the mooring barges. One 1¼-inch steel cable, whose end became fouled in the drift, was parted by the strain, and another of the same size dragged out its anchorage, and being dragged off by the drift was lost. The two pieces of the parted cable were recovered.

At the foot of the older work was found the usual pocket, which invariably forms at the end of a revetment, and here a connecting mat was necessary. This is 35 feet wide and 147 feet long.

As soon as the mat work was completed the mat plant, together with the larger part of the force, was taken to Luxora, there to complete the in the meantime decided upon further extension of the Fletchers Bend revetment. Headquarters remained at New Madrid a while longer, so that the assistant in charge could personally supervise the grading of the bank, which from its composition promised to give trouble. Grading was begun December 9 with one machine and three jets, but the bank begun at once to cave and gully badly, caused by too much water. Two of the three jets were then shut off, and thenceforward only one jet was used, with reasonably fair results, although brush packing at the foot of the slope had to be resorted to several times to prevent caving. One hundred feet of bank at the head of the new work could only be roughly graded with the grader, being afterwards perfected by hand dressing. Grading was completed December 17 and headquarters moved to Luxora, a small force under Receiver of Materials Prewitt being left behind to complete the paving. The later work was done in the usual manner and was carried up as high as that of the older work, which is at about the 33-foot stage.

All work, including the transfer from contractors' onto United States barges of 584 cubic yards of stone left over, was completed on December 31, when the force was paid off and all remaining plant towed to Luxora.

As the bank is largely composed of fine sand, some damage from rain wash may be expected on the paved slope until such time as a complete submergence by the river has silted up all the interstices in the riprap.

All common labor was self-subsisting, but as sleeping accommodations in town were limited, a considerable part of the force were allowed to sleep on the large quarter boat brought from below. One dollar and twenty cents per day was paid for labor.

Brush and poles were furnished by Hunter & Frey, at $1.04 per cord for the and $2 for the latter, delivered on United States barges at contractors' camp. ditions as to overhaul and moving of camp were the same as those for the works. The cost of towage per cord of material was $0.547, which appear high. However, it should be considered that owing to bad weather and scar brush, the latter involving frequent changes in location of camps, the to never could get a full tow of barges, having frequently to return to the wor one or two barges.

The reliance upon obtaining labor at such a small town as New Madrid recommended, as it is fruitful of delays in the progress of the work. At thi we never had more than a two-thirds force, while frequently, if the weather suit the men, we had only about one-fourth of the required number.

Repairs to and preservation of existing works.—The only damage of any conse sustained by the works on Plum Point Reach during the preceding high period was at Daniels Point and at the juncture of the 1895–96 work wit built in 1889. During the six years interval between the final completion revetment at this place the bank above the older work had been caving bac siderably, thereby leaving the head of the old work very much exposed to from above and in the rear. When the extension of 1895–96 was construct head of the older work appeared solid and uninjured, but in order to avoid a of damage much additional stone was distributed around the head of it, in order extra solidity to it. After the subsidence of the high water of 1896 it was that what was formerly the head of the old work had caved off and a ne point lower down had formed. This cave was 400 feet long and extended bac the bank 120 feet. An examination made before submitting a project for showed an increase of from 10 to 30 feet above former depths, thus giving pla dence that the old subaqueous revetment, which was of the woven type of 2 mat, was practically destroyed.

The proposed plan of repairs was to build a foundation mat of proper dim and a three-tier crib dike of brush and stone, the dike to be rooted in the indentation of the shore line and projecting thence 240 feet outstream.

Before the plant for the construction of this work became available the rive rising, and by the time the foundation mat was sunk it had attained a stag feet, Amelia gauge, and rising rapidly. Even at the very lowest water this l has been a most difficult one to work over, on account of the strong eddies and bo with, and these difficulties increase with a rising river. It was apparent that t out the work as planned would involve material difficulties and probable loss, b under the then conditions of the river at this place it was considered impos successfully sink so large a crib as the first one would be. It being, howeve sidered important to do some work here that would if possible check further on the work above and below, it was decided to modify the original project, a regarded the dimensions of the cribs, by placing cribs of only about half of t templated length. These could, if found necessary to do so, be extended length at the next low-water period.

The river continued to rise during the entire period of construction, and time the last crib was down it had attained a stage of 19 feet, Amelia gauge.

Cribs Nos. 1 and 2 were placed without the slightest mishap, but No. 3 wa turned in attempting to sink it. It was turned back, reballasted, and succe lowered into position.

Construction of the foundation mat, which is 277 feet wide by 267 feet lon begun on December 26, and sunk January 6, 1897. Construction was dela frequent spells of bad weather. Mat was constructed with fascines longitudi

Crib No. 1, begun on the 10th, was sunk on the 16th of January. It is 1 long, 30 feet wide, and 8 feet high at outer, tapering to 6 feet at the shore end

Crib No. 2, 121 by 20 by 8 feet at outer and 7 feet high at shore end was s January 21.

Crib No. 3, 119 feet long, 10 feet wide, and 6 feet high at the outer end, ta to 4 feet at the other, was sunk on the 26th. Each crib is 20 feet shorter at t stream end, but projects farther into the bank than the underlying one. Th was properly excavated for the reception of the ends, and a sufficient quan spalls and riprap was piled around them to prevent cutting or undermining.

As now constructed, it is believed that this spur will prevent any further d to the work immediately below until such time as it can be extended farther

Other repairs to existing works consisted in regrading a portion of sect Fletchers Bend revetment, and repaving it. The damage here was caused decay of the brush shore work and insufficient stone ballast. All the old sto broken up to proper size and the deficiency in stone supplied with some take the storage pile.

About 200 feet of the revetment lying just below the groin at the head, t badly damaged before this groin was constructed, was not worked upon, a believed that the groin will prevent further damage there.

The river having cut around the root of the crib constructed the previous year at the foot of section E, an extension of 30 feet well founded into the bank and heavily wrapped with stone was added.

At Daniels Point a small fault in the paving of the work of the previous year, which was caused by a vertical settlement, was regraded and repaved.

At New Madrid several places were found in the work of former years that had either been scantily paved or else denuded of stone by running ice, and these were repaired.

Condition of works.—At the close of the past low-water season the condition of all the modern revetment work was, with the exception of the fault at Daniels Point, first-class. Gold Dust Dam showed no further settlement or damage beyond that reported in my last annual report.

The depression in the dam near the Tennessee shore, so far from being detrimental to the stability of the structure or to the ultimate object of this piece of work, may be considered as a means of accelerating the filling up of that part of the chute lying below the dam.

The upper Fletchers Bend revetment, and that at the upper half of lower Osceola Bar, both of which works were put in in 1883–84, are more or less broken up from the low-water line up, and now that very extensive caving has begun at the head of the former and below the foot of the latter work, I consider their repair and extension quite important, for not only will this unchecked caving produce injurious effects upon the crossings immediately below, but it is also a serious menace to the permanency of the works.in the vicinity of the caving.

At upper Osceola Bar caving has been quite active for nearly two years, from New Haven down to the head of the 1895 work. Upper Osceola Bar forms, now that the closure works in the chute have entirely disappeared, the only barrier to the entrance into that chute of the main river or part of it. This chute has been closed at a large outlay of money, and as its reopening would entirely destroy the beneficial effects of the works from New Haven down to the foot of Bullerton Towhead, I consider the application of some means to avert this reopening of the utmost importance.

My report upon the caving at the above-mentioned three localities, together with suggestions as to the remedy applicable, was forwarded you on March 2, 1897, and as this report treats fully on these matters nothing more need be said here except to once more respectfully invite your attention to the matter.

Navigation over the entire reach has been most satisfactory during the entire past low-water season, and a gratifying fixedness of the various crossings has been observed.

The channel between the foot of Bullerton Towhead and Craighead Point was at first somewhat erratic in its choice of final location, but as it has now for some time been along the Arkansas shore, it is probable that it will remain there. This location eliminates the vexatious crossing over to Yankee Bar and thence back to the Arkansas side.

It is probable that after the subsidence of the present flood some damage to the Daniels Point work of 1889, repaired in 1892 and 1895, will be noted. The subaqueous work is believed to be practically intact, and the damage, if any, will be found along a zone extending 15 to 20 feet above the zero contour. Soundings taken in 1895 show that the under water part of the bank is very steep—too steep, in fact, to hold work of the ordinary kind. In fact, during the repairs, several connecting mats slid down the slope despite their being heavily ballasted and well anchored to the bank, hence should any further damage occur here the only feasible way, in my estimation, is to build short spurs or buttresses against the bank at suitable intervals.

Annual abstracts of expenditures for the various works, together with sketch maps showing the location of work done, are forwarded herewith.

Respectfully submitted.

AUG. J. NOLTY, *Assistant Engineer.*

Capt. GRAHAM D. FITCH,
Corps of Engineers, U. S. A.

REPORT OF MR. WILLIAM GERIG, ASSISTANT ENGINEER, ON WORK OF IMPROVING HARBOR AT MEMPHIS, TENN.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., February 27, 1897.

CAPTAIN: I have the honor to submit the following report of work done under my charge at Memphis Harbor for the season of 1896:

Project.—The project embraced the revetment of the bank 1,200 feet southward from the lower end of the work of 1894.

The revetment comprised the placing of a thick fascine mat, 300 feet wide from the

zero stage, and paving the upper bank with a layer of broken stone abou
thick and extending to about the 20-foot stage of the river, or to the clay st

Construction.—The plant was brought here and work begun on October 1
season was favorable, the river remaining nearly stationary at the 3-foot ma
ing the entire work. Only one and one-half days were lost by rain, but t
was delayed in addition four days on account of shortage in the brush sup
mostly to the sinking of the contractor's derrick boat.

Labor and material.—Labor was ample and of good quality. The wages pa
$1.20 per day of eight hours. The maximum force employed was 234. Br
poles were obtained by contract at 97 cents per cord for the former and $1.50
for the latter, delivered on Government barges at the camps, which were fr
20 miles below the work. The cost of towage per cord of brush or pole
cents.

Stone was obtained by contract delivered on Government barges at We
phis, Ark. The prices paid were $1.44 per cubic yard for riprap and $1.29 fo
The stone was quarried at Williford, Ark., and brought to the delivery p
railroad. The towage of the stone cost about 5 cents per cubic yard.

Fascine mat.—But one mat was constructed and was built in the usual
work beginning October 20 and ending with its sinking, November 11. It
was 1,212 feet, width 300 feet, containing 3,636 squares. The head was lo
Station 13+20 and lapped the foot of the mat placed in 1894 about 25 feet.

Connecting mats.—No connecting mats were necessary here as the bank w
regular and the river mat was thrown on the bank.

Grading.—No hydraulic grading was done as the bank had a good natur
This was trimmed up by hand shoveling as the paving advanced, the materi
cast on top of the paving. The total cost of hand grading was $303.02, or
per linear foot of bank paved. This is charged in the paving account.

Paving.—This work was begun November 12 and completed November 2
1,212 feet long, extending from about 3 feet above zero to the 19-foot stage, e
stratum of clay. Its average thickness was 12 inches, of which the lower
was quarry spalls and the upper 8 inches small riprap, closely placed.

Transmitted herewith is a tabulated statement of expenditures, also map
ing the location of the work.

Respectfully submitted.

Wm. Gerig, *Assistant En*

Capt. Graham D. Fitch,
Corps of Engineers, U. S. A.

REPORT OF WILLIAM GERIG, ASSISTANT ENGINEER, UPON CONSTRUCTION W HELENA, ARK.

United States Engineer Offic
Memphis, Tenn., March 9

Captain: I have the honor to submit the following report of work done u
charge at Helena, Ark., for the season of 1896–97:

The original project was curtailed, since only $64,000 was appropriated,
embrace the following:

1. The revetment of the lower portion of Helena front from the lower end
No. 4 downstream for a distance of about 2,100 feet.
2. The raising of the cribs of Dike No. 4 to about the original grade.
3. The placing of one brush and stone spur dike in the large pocket betw
tions 20 and 23 to break up the high-water eddy actions there.
4. The repairing of the exposed ends of dikes Nos. 1, 2, and 3 by the add
stone where necessary.

The revetment comprised the placing of two fascine mats, about 260 fe
and paving the upper bank with riprap up to about the 25 foot stage.

Construction.—The first tow of the fleet arrived at Helena from Memphis
on November 21, and preliminary work, such as digging deadmen, etc, wa
diately begun. The remainder of the plant and outfit arrived on November

The season was not favorable, the river rising four times to about the m
during the work. Two days were lost by rain, three by holidays, and three
weather.

Labor and material.—Labor was ample and of fairly good quality. Th
were the same as paid at Memphis. The maximum force employed was 342.

Brush at $1.04 and poles at $2 per cord, delivered on Government barge
camps, were obtained by contract. The camps were from 20 to 30 miles ab
work. The cost of towage per cord of brush or poles was 32 cents.

Stone was obtained by contract, delivered on the contractors' barges at th

The prices paid were $1.64 per cubic yard for riprap and $1.49 for quarry spalls. The stone was quarried on the Mississippi and Ohio rivers above Cairo, Ill., and at Williford, Ark.

Fascine mats.—The head of mat No. 1 was located about 110 feet below hub No. 4. This mat was begun November 27, and was designed to be about 1,100 feet long, but owing to a rapid rise of the river its length was curtailed and the piece was sunk December 5. It was built in the usual way and contained the standard amount of material. Its length was 555 feet and width 280 feet. When this mat was begun the Helena gauge read 9.8 feet, and on the day it was sunk 19 feet.

The mooring piling was broken on December 4 and the mat moved toward shore some 20 feet, but no other damage was done. A bent of three piles was immediately driven to prevent further movement.

Before the drift had begun running, festoons of chains were hung from the upstream side of the mooring barges, which caught the drift and held it. Fender barges were not used until December 2, as there were no empty barges available prior to this time. These caught the drift and prevented it from being caught by the mooring barges.

By the morning of December 5 the current had become very rapid, and both the fender and mooring barges had a large mass of drift above them. The timberheads on the fender barges had been cut nearly half in two by the steel headlines. A tow of stone arrived that morning, and, as the mat had been partly ballasted with stone stored here, it was sunk in the afternoon without any accidents.

When the river had commenced falling again at Helena, work was begun December 14 on mat No. 2. The head was 3 feet square and 300 feet long. Twelve steel shackle lines, of diameters from 1 to 1¼ inches, were fastened to this mat in the usual manner. Eight of the largest ones were on the outside half, as the maximum current was there. In addition to the standard amount of wire strand, this mat had four ½ and one 5/16 inch strands near the channel edge, thus increasing the breaking strain at this point 33,640 pounds. Additional strands used in other parts of the mat made a total increase of 25 tons. This mat was completed December 23; its length was 1,075 feet, width 300 feet for a distance of 440 feet from the head, thence 280 feet. In the afternoon of that day, while attempting to sink it, it tore in two, about 430 feet from the head, after 350 feet or more was on the bottom. The channel edge broke first, and, driving the lower part against the bank, broke the remaining strands one by one and went adrift. At no time was there an excessive strain on the shackle lines, and they were all in good shape.

The cause of the accident was that the combined strength of the wire strands in this mat was not sufficient to stand the force of the current.

On December 22 some observations were made with surface floats to determine the velocity of the current along the channel edge of the mat. It was found to be 8¼ feet per second, the gauge reading 16 feet, and had probably increased before the mat was sunk, as the river was still rising. The rapid current at this place was partly due to the increased slope caused by Dike No. 4, and probably also due to the fact that the upstream side of the mooring barges, with drift 4 feet thick under them, was only 25 feet from the dike, therefore decreasing the area the water had to pass through. This drift consisted of trees of all sizes, saw logs, and cottonwood bark, and I think very little succeeded in making its way under the mat, as only the standard amount of stone was required for proper ballasting.

Since the river had commenced falling again, mat No. 3, placed so as to cover the space occasioned by the break in mat No. 2, was begun on December 28, and completed with its sinking on January 7, just before the river had commenced rising rapidly again. Its width was 280 feet and length 700 feet, overlapping mat No. 1 about 30 feet and mat No. 2 about 50 feet. It contained 38,174 pounds of wire strand, the combined breaking strain of which was 273 tons, against 104 tons on the mat that was broken. These figures do not include the sewing strands. About 7,000 pounds of strand and 1,000 cable clips were made on the works, as sufficient quantities could not be obtained without delay.

The following are the quantities of material used per square in this mat:

Brush	cords	1.25
Poles	do	.059
Stone	cubic yards	.719
Wire strand	pounds	19.480
Wire, steel, No. 12	do	3.66
Wire, silicon bronze	do	.89
Staples	do	.250
Cable clips		1.544

Owing to the lateness of the season and the high stage of the river, no more river mats were built.

Connecting mats.—It was necessary here to build connecting mats of various lengths

and widths, aggregating 1,079 squares. Had the river remained stationary
stage, a large part of these would have been dispensed with.

Grading.—No hydraulic grading was done, since generally the bank had
slope. Some material had to be moved about 100 feet in order to fill lo
there being no alternative, owing to the close proximity of the levee. The
of hand grading was $688.89, or $0.428 per linear foot of bank paved. This is
in the paving account.

Paving.—This work was begun on January 8 and completed January 28,
feet long, and contained 12,967 square yards. At stations 13 to 15 the paving
from the 15-foot to the 27-foot stage; at stations 15 to 17 it extended to th
stage; stations 17 to 19 to an average of about the 40-foot stage; stations 19 t
to an average of about the 26-foot stage. A surplus amount of stone wa
between the water's edge and the zero contour, and this can be properly
small expense when the river reaches a low stage.

Repairs to Dike No. 4.—The top crib on Dike No. 4 had decayed and wa
away. This was replaced by a wedge-shaped crib 100 feet long, 40 feet
feet thick at upstream end, and 7½ feet thick at the lower end. The lower
flush with lower edge of bottom crib. This was sunk on January 26, an
cient amount of stone was placed on top to raise it about to the original g

Spur dike.—A spur dike was constructed at 21+130 and extended from t
the levee to the water's edge on top of the knoll. It was built of brush, p
stone, and was of the usual design. Its height was 6 feet, width 12 feet, a
350 feet. A small piece of sill mat was required in the pocket; the remaind
blue clay and required no sill mats. A strip about 20 feet wide was paved
side of the spur. The upper part was built at a high stage of the river du
temporary suspension of mat work. The remainder was finished January 2

Repairs to Crib Dikes Nos. 1, 2, and 3.—The exposed ends of Crib Dikes No
were repaired to the 12-foot stage by placing more stone on them. No
done on Dike No. 1 since the river was too high.

Operations were suspended on January 28, and the plant started for Mem
account of floating ice, the last tow of the plant did not arrive at Mem
February 12.

The work was greatly hampered by the rises of the river, swift curr
heavy drift, yet the project as modified could have been completed with
available, even after having lost the piece of mat—which cost, say, $7,50
been possible to continue operations during another thirty days.

Transmitted herewith is a tabulated statement of expenditures; also a m
ing the location of the work.

Respectfully submitted.

WM. GERIG, *Assistant E*

(Through Mr. W. M. REES, Assistant Engineer in charge.)

REPORT OF MR. CHARLES LEVASSEUR, ASSISTANT ENGINEER, ON OPERAT
REMOVAL OF NONCONNAH ROCK.

UNITED STATES ENGINEER OFFI
Memphis, Tenn., March 1

CAPTAIN: I have the honor to submit the following report on the oper
Nonconnah Rock from October 5, 1896, to January 25, 1897:

The object of the work was the destruction, by submarine drilling and
of Nonconnah Rock, situated 4 miles below the Memphis Railroad Bridge
feet from the Tennessee shore.

On September 25, 1896, I made a survey of said rock, in view of ascerta
exact location and the depth of water over it. The result of this survey, s
one of the maps accompanying this report, indicates that an area of 336.
feet of the rock was under a depth of water varying from 3 feet to 7 feet b
zero of the Memphis gauge.

On October 1, 1896, Mr. William Gerig, United States assistant engineer,
force organized and the plant towed from the United States fleet to the si
work. On November 15, 1896, I was ordered to relieve Mr. Gerig and to tak
of the work.

The plant consisted of a drilling platform and pontoons, pile driver No
mooring barge, two flats, and quarter boat *Mississippi*. The U. S. steambo
Abbot was used as tender.

The drilling platform, built especially for this work from plans made by M
Rees, United States assistant engineer, was composed of a floor or platform
drilling machine was placed and worked. This floor was provided at each
one spud 20 feet long, 10 by 10 inches, running through a well. To this
was framed an overhead truss, used for handling drilling tools and pipes

raising and lowering said tools and hydraulic jet pipe. The platform was floated on the two pontoons, lashed lengthway to the floor frame.

The pile driver, being fitted with a "Hooker pump," was used altogether for hoisting and hydraulic purposes. Steam necessary for the steam drill was furnished by the pile-driver boiler.

The force employed was composed, outside of the office force, of 1 foreman and diver, 1 steam-drill engineer, 1 pile-driver engineer, 1 blacksmith, 1 cook and waiter, and 10 laborers.

The foreman, when submarine observations were necessary, was employed as diver. One of the laborers was then employed as diver tender.

The method of operation was as follows:

The mooring barge was anchored, by means of wire cables and Chinese anchors, 500 feet above the upstream edge of the rock. From this barge, with the aid of the pile-driver hoisting machine, flats, pile driver, and drilling platform were swung into position. The mooring barge was so located that the whole area of the rock could be covered by taking in or paying off on two side cables leading from it to the platform. The drilling platform, floating on pontoons, was dropped by said process over the exact part of the rock where drilling operations were to be conducted, the spuds lowered down, and the platform raised on spuds by means of rope and tackle wound on drum of hoisting machine, or by ratchet fixed to spuds and floor of platform.

The location of platform was ascertained by instrumental observations from shore. As soon as the platform was raised, soundings were taken every 5 feet over the space covered and compared with soundings of the survey made September 25, 1896. If differences in soundings were shown, said differences were noted on map.

An iron pipe 4 inches in diameter, and of a length sufficient to project 1 foot over the surface of the water, was placed on top of rock, rammed down as far as possible, and made fast by four lines leading at different angles to the floor timber of platform. This pipe was to prevent the hole to be drilled from being filled by sand or sediment. The drilling tool, 2¼ inches in diameter, was placed inside the 4-inch iron pipe, the drilling machine shipped up over said pipe and connected to tool, and drilling operation started. The holes were drilled to an average depth of 4½ feet.

When the first hole was drilled, the machine moved over a second 4-inch pipe placed (as above described) during the first drilling operation. The first hole was then washed by hydraulic jet set inside of the 4-inch pipe, and a cartridge composed of 4½ pounds of dynamite, with proper exploders and insulated electric wires attached, was rammed to the bottom of hole through the same 4-inch pipe and said pipe raised up. These operations were continued all day. At the end of the working day the platform and pile-driver were hauled up near mooring barge and loaded holes exploded by electric battery.

In the morning of the next day survey was made over the area blasted the evening before, and soundings taken platted on working sheet. At the end of each month survey was made to obtain the total amount of rock destroyed. At the end of the work soundings were taken over the area of the rock. Map of survey made January 25, 1897, accompanying this report shows these soundings. From the examamination of said map 30,350 square feet of rock was found to have been disturbed and 2,333 cubic yards of rock destroyed.

On January 25, 1897, the high stage of the river forced the operations to be suspended. During nearly half of the working period the stage of the river was not favorable to the rapid prosecution of the work, the variation of the Memphis gauge having been from 6 to 18 feet above zero.

During a working day with low stage of the river an average of 9 holes were drilled and blasted; with high stage only 6 holes could be drilled and blasted.

The cost of the operations at Nonconnah Rock is as follows:

Labor and superintendence	$2,217.18
Subsistence	754.65
Dynamite	448.00
Wire, insulated and exploders	76.63
Coal	195.94
Oil and engineer supplies	42.07
Plant	655.70
Total cost	4,390.17

Making a cost of $1.881 per cubic yard of rock destroyed.

I have the honor to transmit herewith a general abstract of expenditures at Nonconnah Rock, and original tracings of surveys, September 25, 1896, and January 25, 1897.

Respectfully submitted.

CHAS. LEVASSEUR, *Assistant Engineer.*

Capt. GRAHAM D. FITCH,
Corps of Engineers, U. S. A.

Financial statement.

IMPROVING MISSISSIPPI RIVER, FIRST AND SECOND DISTRICTS.

July 1, 1896.	Balance unexpended	$360,891.70
June 30, 1897.	Amount appropriated and allotted since last statement	217,875.00
	Amount refunded account overpayments	38.44
	Amount received on account proceeds of Government property	40.25
	Amount received from B. F. Dame for rent of island in Mississippi River, near Australia, Miss., for year 1897	1.00
June 30, 1897.	Amount expended from July 1, 1896, to date	358,590.07
	Amount deposited to credit Treasurer United States on account proceeds of Government property	40.25
	Amount deposited to credit Treasurer United States on account rent of island in the Mississippi River, near Australia, Miss., for year 1897	1.00
	Amount deposited to account "Stationery, War Department, 1897"	24.80
	Amount of Treasury settlement No. 1841	.20
	Amount transferred to Capt. H. E. Waterman, secretary Mississippi River Commission	62,210.11
	Amount transferred to Third district	19,000.00
	Amount transferred to Fourth district	19,000.00
	Balance unexpended	
	Outstanding liabilities	10,053.92
	Amount covered by uncompleted contracts	25,900.00
	Balance available	

Amount that can be profitably expended during fiscal year ending June 30, 1899

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Abstract of proposals for furnishing brush, poles, and stone, received in respons tisement dated May 20, 1896, and opened June 1, 1896, by Capt. Graham Corps of Engineers.

No.	Name and address of bidder.	Brush, per cord.	Poles, per cord.	Limestone.	
				Riprap, per cubic yard.	Quarry spalls, per cubi yard.
				Cents.	*Cents.*
1	Earle E. Burke, Neelys Landing, Mo			49½	45
2	C. L. Howard, Elizabethtown, Ill			50	47
3	Edmund Ligon & Co., Searcy, Ark			a 46	a 46
4	Nelson Sessons, Grand Tower, Ill			48½	38
5	Simon G. Wheeler, Rosiclare, Ill			60	57
6	Hunter & Frey, Memphis, Tenn	a $1.04	a $1.60		

a Accepted.

Abstract of proposals for levee work in Upper Yazoo Levee district, received in response to advertisement dated July 14, 1896, and opened July 30, 1896, by Capt. Graham D. Fitch, Corps of Engineers.

No.	Name and address of bidder.	Station 279 to 335, per cubic yard.	Section 10 southward, per cubic yard.
		Cents.	*Cents.*
1	T. Aderholdt, Friars Point, Miss.	10.44	11.74
2	J. B. Lewis & Co., New Gascony, Ark.	10.50	11.50
3	Andrew Outzen, Memphis, Tenn.	9.45	10.99
4	Robert Johnson, Memphis, Tenn.	10.20	10.49
5	L. C. Dresbach & Co., St. Thomas, Ark.	9.37	11.70
6	Batt O'Brien, Memphis, Tenn.	9.73	9.44
7	Manning & Gibson, Greenville, Miss.	....	11
8	W. M. Forrest, Memphis, Tenn. *a*	9	11½
9	Arnold & De Garis, Memphis, Tenn.	9½	11¾
10	Hugh Morgan, Memphis, Tenn.	....	12⅜
11	N. J. Roach, Memphis, Tenn.	9.24	11.45
12	T. Mike, Memphis, Tenn.	8.94	11½
13	McCadden & Co., Memphis, Tenn.	*b* 8.20	*b* 9.20
14	Hugh McCarten, Memphis, Tenn.	9.44	10.99
15	Banks & Morrow, Memphis, Tenn.	9.45	12

a Will do both pieces at 10.75 cents. *b* Accepted.

Abstract of proposals for levee work in Lower St. Francis and White River Levee districts, received in response to advertisement dated August 6, 1896, and opened August 24, 1896, by Capt. Graham D. Fitch, Corps of Engineers.

No.	Name and address of bidder.	Lower St. Francis Levee district, Station 3522 to 3734, per cubic yard.	White River Levee district.	
			Station 1520 to 1392, per cubic yard.	Drainage ditches.
		Cents.	*Cents.*	*Cents.*
1	J. C. Hodge, Memphis, Tenn.	....	18	14
2	Timothy Sullivan, Memphis, Tenn.	9.95	18¾	18¾
3	Arnold & De Garis, Memphis, Tenn.	11	14⅝	15⅝
4	T. Mike, Memphis, Tenn.	10.74	....	....
5	Andrew Outzen, Memphis, Tenn.	....	14.94	14.94
6	J. H. Cary, Memphis, Tenn.	*a* 8.99	....	....
7	Robert Johnson, Memphis, Tenn.	14.24	16.99	*a*12.50

a Accepted.

Abstract of proposals for furnishing brush, poles, stone, wire strand, clips, and manila rope, received in response to advertisement dated August 24, 1896, and opened September 7, 1896, by Capt. Graham D. Fitch, Corps of Engineers.

No.	Name and address of bidder.	Brush, per cord.	Poles, per cord.	Stone.		Wire strand.			Wire-rope clips.		Manila rope, per pound.
				Riprap, per cubic yard.	Spalls, per cubic yard.	½-inch, per pound.	7/16-inch, per pound.	⅜-inch, per pound.	7/16-inch, each.	½-inch, each.	
						Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Fred Hanger, Little Rock, Ark.	......	......	*a* $1.87	*a* $1.87	......	......	......	......	......	......
2	Fred. Hartweg, Cincinnati, Ohio	......	......	*b* 1.84	*b* 1.69	......	......	......	......	......	......
3	John Barrett, Cincinnati, Ohio	......	......	*b* 1.48	*b* 1.48	......	......	......	......	......	......
4	Thompson C. Gill & Co., Philadelphia, Pa.	......	......	......	......	4.49	3.99	3.74	9.99	17.49	7.74
5	Geo. F. Ernst, St. Louis, Mo.	......	......	......	......	3.43	3.04	3.02	5.35	8.42	......
6	Joseph Evins, Dardanelles, Ark.	$1.25	$2.25	......	......	......	......	......	......	......	......
7	Edward Healy, Louisville, Ky.	......	......	*a c*1.44	*a c*1.29	......	......	......	......	......	......
8	H. E. Coffin, Memphis, Tenn.	......	......	......	......	*c*3.25	*c*2.80	*c*2.90	5.25	8.50	6.09
9	Geo. Skene, Memphis, Tenn.	......	......	......	......	3.30	2.90	*c*2.90	4⅞ 3¼ 4⅛ *c*3.93	7⅞ 3¾ 6¼ *c*5.43	*c*5⅝
10	Hunter & Frey, Memphis, Tenn.	*c*.97	*c*1.50	......	......	......	......	......	......	......	......

a Delivered on Government barges. *b* Delivered on contractors' barges. *c* Accepted.

Abstract of proposals for furnishing brush, poles, stone, wire, wire strand, silicon bronze wire, and clips, received in response to advertisement dated October 21, 1896, and opened November 2, 1896, by Capt. Graham D. Fitch, Corps of Engineers.

No.	Name and address of bidder.	Brush, per cord.	Poles, per cord.	Riprap stone. Contractor's barges at Helena, per cubic yard.	Riprap stone. Government barges at Memphis, per cubic yard.	Quarry spalls. Contractor's barges at Helena, per cubic yard.	Quarry spalls. Government barges at Memphis, per cubic yard.	Wire, per pound.	Wire strand. ⅜-inch, per pound.	Wire strand. 5/16-inch, per pound.	Wire strand. ¼-inch, per pound.	Silicon bronze wire, per pound	Wire-rope clips. 5/16-inch, each.	Wire-rope clips. ½-inch, each.
								Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1	John Barrett, Cincinnati, Ohio			a$1.64		a$1.49								
2	Fred. Hartweg, Cincinnati, Ohio			1.90		1.65								
3	P. Pidgeon, Memphis, Tenn							1.80	4 1/16	3.20	a2.65	16¾		
4	Edward Hely, Louisville, Ky				$1.40		$1.25							
5	Harry E. Coffin, Memphis, Tenn							a1.70	a2.70	2.85	3.20	a13⅛	a3¾	6¾
6	George Skene, Memphis, Tenn							1.78⅛	3.17½	a2.70	2.80	17½	4.49 4⅝ 3¾ 4⅛	a6.24 7⅞ 3⅞ 6⅞
7	Hunter & Frey, Memphis, Tenn	a$1.04	a$2.00											

a Accepted.

Abstract of proposals for levee work in Lower St. Francis, White River, and Upper Yazoo levee districts, received in response to advertisement dated October 30, 1896, and opened November 9, 1896, by Capt. Graham D. Fitch, Corps of Engineers.

No.	Name and address of bidder.	Lower St. Francis Levee district, station 3734 southward, per cubic yard.	White River Levee district. Station 512 + 90 to Station 526, per cubic yard.	White River Levee district. Station 1050 northward, per cubic yard.	Upper Yazoo levee district, section 13 southward, per cubic yard.
		Cents.	Cents.	Cents.	Cents.
1	James H. Cary, Memphis, Tenn	17	15	18	10¾
2	E. B. Mantle, Memphis, Tenn		11.95		12.45
3	Ben. Talley, Memphis, Tenn				a9.90
4	L. C. Dresbach, Memphis, Tenn	a14½	a11	a14½	11 1/10
5	McCadden & Co., Memphis, Tenn			22.40	12.60

a Accepted.

Abstract of proposals for levee work in Upper Yazoo, Lower St. Francis, and White River levee districts, received in response to advertisement dated December 16, 1896, and opened December 26, 1896, by Capt. Graham D. Fitch, Corps of Engineers.

No.	Name and address of bidder.	Upper Yazoo Levee district, Station 710 southward, per cubic yard.	Lower St. Francis Levee district, Station 3805 southward, per cubic yard.	White River Levee district, Station 994 northward, per cubic yard.
		Cents.	Cents.	Cents.
1	Robert Johnson, Memphis, Tenn	a10.99	b17.49	15.99
2	Ben. Talley, Memphis, Tenn	12.24		
3	Jas. H. Cary, Memphis, Tenn	17	b17	19
4	Patrick McCadden, Memphis, Tenn	18		a15.70

a Accepted. b Rejected.

Abstract of proposals for furnishing one stern-wheel towboat, received in response to advertisement dated January 2, 1897, and opened February 1, 1897, by Capt. Graham D. Fitch, Corps of Engineers.

No.	Name and address of bidder.	Price.
1	Elizabeth Marine Ways Co., Elizabeth, Pa	$38,900
2	Ed. J. Howard, Jeffersonville, Ind	[a]25,900
3	Thomas M. Rees, Pittsburg, Pa	34,000

[a] Accepted.

IMPROVING MISSISSIPPI RIVER, FIRST AND SECOND DISTRICTS.

List of contracts entered into by Capt. Graham D. Fitch, Corps of Engineers, in force May 31, 1897.

Name and address of contractor.	For what made.	Date of approval.	Date of beginning work.	Expiration of contract.	Remarks.
		1897.	1897.	1897.	
Robert Johnsen, Memphis, Tenn.[a]	Levee work, Upper Yazoo Levee district.	Feb. 1	Jan. 15	Mar. 15	Completed.
Patrick McCadden, Memphis, Tenn.[a]	Levee work, White River Levee district.	Feb. 9	Jan. 18	....do ...	Time of completion extended to June 1, 1897.
Jas. H. Cary, Memphis, Tenn.[a][b]	Levee work, Lower St. Francis Levee district.	....	....	Apr. 15	Time of completion extended to Aug. 1, 1897.
Ed. J. Howard, Jeffersonville, Ind.	Stern-wheel towboat.	Feb. 26	....	Aug. 1	

[a] These agreements were entered into under provisions of river and harbor act approved June 3, 1896. Funds for their payment are yet to be appropriated for fiscal year ending June 30, 1897.

[b] Written agreement entered into in compliance with instructions of Chief of Engineers of February 1, 1897.

APPENDIX 9.

REPORT OF FIRST LIEUT. H. C. NEWCOMER, CORPS OF ENGINEERS, UPON OPERATIONS IN THE THIRD DISTRICT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., May 20, 1897.

COLONEL: I have the honor to submit the following report of operations in the third district, improving Mississippi River, from May 1, 1896, to May 1, 1897:

Capt. C. McD. Townsend, Corps of Engineers, was in charge of the district until July 27, 1896, when Capt. Graham D. Fitch assumed temporary charge, being relieved by me August 17, 1896, in compliance with Special Orders No. 168, Adjutant-General's Office, dated July 18, 1896.

The third district extends from the Coahoma-Bolivar County line, on the left bank (365 L), and the mouth of the White River, on the right bank (393 R), to the latitude of Warrenton, Miss. (607 L). In its improvement, works of bank protection have been executed at Lake Bolivar Front, Ashbrook Neck, Greenville Harbor, Lake Providence Reach, and Delta Point. The systematic improvement of Lake Providence Reach was attempted, and levees have been constructed and enlarged in the Upper Tensas and Lower Yazoo Levee districts. All of these localities are shown on the accompanying map of the third district.

The operations of the past year have included repairs to the broken revetment at Greenville and Louisiana Bend, the construction and maintenance of levees, and the care of plant.

LAKE BOLIVAR FRONT (417 MILES BELOW CAIRO).

The revetment at this place was built to hold a bank whose caving endangered a large levee across the head of Lake Bolivar. Four thousand two hundred and fifty linear feet of revetment were constructed in 1888–89, and repairs were made in 1889, 1892, and 1893. Details of the work are given in the Annual Reports of 1889, page 2704; 1890, page 3252; 1893, page 3752, and 1894, page 2919, and maps accompany the reports of 1889 and 1890.

No work has been done since 1894. The surveys of recent years show a fill over the revetment, and it is protected by a bar making downstream from the foot of Island No. 76. The revetment is apparently in good condition for a length of about 3,775 feet measured along the shore edge of the mats. No extension is considered necessary. The total expenditures have been $145,358.08.

ASHBROOK NECK (446 MILES BELOW CAIRO).

The revetment at this place was built to prevent a threatened cut-off. Two thousand eight hundred and twenty linear feet of revetment were constructed in 1890–91, 4,300 feet in 1891–92, 2,610 feet in 1892–93, 1,475 feet in 1894–95, and repairs to upper bank paving were made in 1893–94.

A levee 7,300 feet long was built along the axis of the neck in 1891–92 to prevent flow across the neck, but it was destroyed in the next flood. Details of the work are given in the Annual Reports of 1891, page 3639; 1892, page 3170; 1893, page 3752; 1894, page 2920, and 1895, page 3805. Maps accompany the reports of 1892 and 1893.

No change has been observed during the year except a slight break in the upper bank paving at Station 107, first noticed September 8, 1896. The defect was not considered of sufficient importance to require repairs. The revetment appears to be in effective condition for a length of about 9,990 feet measured along the shore edge of mats. No extension is considered necessary. The total expenditures have been $428,918.54.

GREENVILLE HARBOR (478 MILES BELOW CAIRO).

The revetment at this place was built to protect the town of Greenville, which was rapidly caving into the river when the work began, in 1887. The first project was to hold the bank with submerged spur dikes consisting of cribs resting on foundation mats. In 1887, 1888, and 1889 twelve crib dikes were built, and one longitudinal pile dike, and mats were placed between some of the spur dikes. Caving continued, however, in the bend above, and during the flood of 1891 the upper dikes were flanked, four spur dikes and the longitudinal dike being carried away. The revetment of the bank above the remaining dikes was then begun, 6,600 linear feet being built in 1891–92, 4,450 feet in 1892–93, and 3,087 feet in 1894–95. Repairs were made to upper bank paving in 1893 and 1894. In the flood of 1894 the upper remaining spur dike was carried away, leaving seven spur dikes still in position. The details of the above operations are given in the Annual Reports of 1888, page 2280; 1889, page 2706; 1890, page 3240; 1892, page 3173; 1893, page 3753; 1894, page 2920; and 1895, page 3805. Maps accompany the reports of 1888, 1889, 1890, 1892, and 1893.

The river and harbor act of June 3, 1896, appropriated $64,000 for Greenville Harbor. Captain Townsend submitted a project June 19, 1896, providing for repairs to the break in the revetment at Station 54 that had occurred during the spring flood, at an estimated cost of $24,000, and an extension of 400 feet to check caving at the head of the revetment, at an estimated cost of $12,000. This project was approved only so far as it related to repairs at Station 54. These repairs were approved by the Mississippi River Commission June 20, 1896, and by the Secretary of War August 5, 1896. Notice of the latter approval was received October 16, 1896. The repairs were made in October and November. A channel mat 300 by 677 feet was sunk, and the upper bank regraded and repaved, at a total cost for labor and material of $24.68 per linear foot of bank protection. The details of the work are given in the appended report of Assistant Engineer Arthur Hider.

Under date of November 4, 1896, I submitted to the Mississippi River Commission a project recommending that no further extension of the revetment be made with the $40,000 remaining from the appropriation of June 3, 1896, but that these funds be held available for making such repairs as may be required from time to time in the existing work, the latter having accomplished its purpose. The project was approved by the Commission November 12, 1896.

On April 5, during the recent flood, a break occurred in the revetment above the town, about range 24, and May 18 another break was reported about range 61. The flood has not subsided sufficiently to permit the extent of the damage to be accurately determined, but the breaks are apparently about 300 feet long at each place. It will probably be necessary to make repairs here during the coming season.

Without deducting these breaks, the length of revetment in effective condition is about 12,165 feet, measured along the shore edge of the mats. There are also about 2,900 feet of bank protected by the dikes.

The total expenditures for this work have been $603,616.33, not including $42,277.10 contributed by the town of Greenville in 1887.

LAKE PROVIDENCE REACH (517 TO 552 MILES BELOW CAIRO).

Earlier works.—This was one of the reaches first selected by the Mississippi River Commission for systematic treatment. The least low-water depths on its crossings before its improvement was undertaken are variously reported as 4½ and 5 feet. The original project provided for giving the low-water channel an approximately uniform width of 3,000 feet, by constructing contraction works, closing all the chutes, and holding the caving banks. Instead of covering the entire reach of 35 miles, however, as originally intended, the works as built were confined to a reach of about 20 miles, from 522 to 542 miles below Cairo. Operations were begun in 1882 and actively prosecuted until 1885, and some repairs were made to these earlier works in 1886 and 1888–89. The Duncansby, Mayersville, Baleshead, and Stack Island systems of dikes were constructed on the Mississippi side of the channel, and the Cottonwood and Elton systems on the Louisiana side, and bank revetment was constructed at Louisiana Bend and Mayersville Island. The total lengths of the various constructions were about as follows: 112,396 feet of pile dikes, 48,238 feet of foot mats between dikes, 16,547 feet of foot mats along the dikes, 5,588 feet of screens in front of the dikes, 13,561 feet of wattling between dikes, 520 feet of shore revetment at the ends of dikes, and 33,476 feet of bank revetment. See Annual Report of 1895, page 3843, for a summary of the work. The details of these works are given in the Annual Reports of 1883, page 2285; 1884, page 2814, and 1885, pages 2748 and 2960. Maps accompany the reports of 1883, 1884, 1888, and 1889.

These earlier works had a beneficial effect on the channel, but they were comparatively weak and difficult to maintain. The Duncansby system was reported as practically destroyed by 1886, the Louisiana Bend revetment by 1887, and by 1889 only portions of the system at Baleshead Bar and Stack Island remained out of all the works that had been built. Parts of these are still in existence, where not exposed to the destructive action of the river.

Louisiana Bend revetment (522 R).—In 1889 active work was resumed. It was decided to revet the caving bank near the head of the reach in Louisiana Bend, hoping thus to give greater permanence to the channel throughout the reach. Six thousand and twenty-four linear feet of revetment were built in 1889–90, 5,224 feet in 1891–92, and 5,835 feet in 1892–93, when further operations were suspended awaiting the results of the experiments with dredging. The type of revetment used was much stronger than that formerly employed, consisting of woven mats below water, 260 to 345 feet wide, and upper bank paving of stone 10 inches thick. Details of the work are given in the Annual Reports of 1890, page 3229; 1892, page 3177, and 1893, page 3754. A map accompanies each of these reports.

It has been necessary each year to make some repairs to the upper bank paving, where sloughs occurred during low-water stages, and in 1892 and 1893 seven short spur dikes of brush and stone were built on the upper bank, across the mouth of Old River, where the high waters caused scouring behind the revetment. During the last low-water season a break appeared in the revetment at range 126, and at the foot of the work continued caving had carried away about 1,200 feet of the revetment. Authority was obtained to repair these defects. Work was begun by the revetment party December 1, 1896, and completed January 14, 1897.

A channel mat 300 by 484 feet was built and sunk at range 126, and another 300 by 763 feet at the lower end of the revetment, the upper bank in both cases being regraded and repaved. The total cost of the work was $23.48 per linear foot.

The details of the work are given in the appended report of Assistant Engineer Arthur Hider.

The length of revetment apparently in effective condition is about 15,820 feet, measured along the shore edge of mats.

Lake Providence revetment (540 R).—This revetment was built to hold a rapidly caving bank that threatened to destroy the important levee across the foot of the lake, and the town of Lake Providence. Four thousand seven hundred and eighty linear feet of revetment were built in the season of 1894–95, and 5,360 feet in the following season, 1895–96. The details of the work are given in the Annual Reports of 1895, page 3806, and 1896, page 3653. A map of the work accompanies the report of 1896.

No repairs have been required during the past year. No extension is considered necessary in the near future. The length of revetment in good condition is about 10,000 feet measured along the shore edge of the mats.

The following table gives the least depths reported on crossings in Lake Providence Reach for the different years:

Year.	Date.	Crossing.	Depth on crossing, feet.	Reading of Lake Providence gage.
1879		Stack Island	5	0.55
1884	August 30	do	10	8.9
1885	October 20	Ben Lomond	13	7.1
1886	September 30	Stack Island	8.5	4.7
1887	September 10	do	7	4.5
1888	October 23	do	9	5.75
1889	November 1	Ajax Bar	7	2.25
1890			11	8.5
1891			7	10
1892	October 23	Ajax Bar	5.5	1
1896	October 30		12	1.6

Extreme low-water depths of 6 to 7 feet have been reported for the years 1893–1895.

The total expenditures for the Reach have been $3,527,137.52.

VICKSBURG HARBOR (599 MILES BELOW CAIRO).

This harbor was practically destroyed for low-water commerce by the cut-off that occurred here in 1876 and the subsequent shoaling of the channel leading from the river to the resulting lake front of the city.

Delta Point revetment.—The first operations undertaken for the improvement of the harbor consisted in revetting the rapidly caving bank at Delta Point, as its continued recession was increasing the distance from the harbor proper to the channel of the river. From 1878 to 1881, before the Mississippi River Commission assumed charge of the work, there were built about 5,400 linear feet of revetment, one mattress spur dike, and two screen dikes, at a total cost of $203,229.87. The details of the work for this earlier period are found in the Annual Reports of 1878, page 637; 1879, page 974; 1880, page 1333; 1881, page 1384, and 1882, page 1502. The river and harbor act of August 2, 1882, placed this work under the supervision of the Mississippi River Commission.

The work of revetment at Delta Point was continued, 1,100 linear feet of revetment being built in the season of 1882–83, 2,200 feet in 1883–84, 2,083 feet in 1884–85, and 1,065 feet in 1893–94. Practically all the work prior to 1882 is destroyed or covered by the later work. Only the mats of 1893–94 have the present standard width of 300 feet, the earlier ones being from 150 to 175 feet wide. Details of the work under the Commission are given in the Annual Reports of 1883, page 2290; 1884, page 2820; 1885, pages 2787 and 2964; 1889, page 2709; 1893, page 3754, and 1894, page 2921. Maps accompany the reports of 1883, 1884, 1888, 1889, and 1893.

About 5,050 linear feet of the revetment are still in position. No extension is recommended at present.

Vicksburg Harbor.—When the harbor was placed under the supervision of the Mississippi River Commission in 1882, a project was adopted for dredging a basin 1,700 by 300 feet, in the harbor, and a canal 150 feet wide to connect the basin with the river channel. Dredging under this project amounted to 350,035 cubic yards in 1883, and was then discontinued until 1888, when it was renewed under a slightly modified project and continued until 1893, amounting during this latter period to 1,729,994 cubic yards, making a total of 2,080,029 cubic yards in all. In 1888 pile dikes were built on the northern side of the basin and the western side of the canal, aggregating 6,800 feet in length. The details of the operations in the harbor are given in the Annual Reports of 1884, page 2821; 1888, page 2282; 1889, page 2710; 1890, page 3234; 1891, page 3628; 1892, page 3180; 1893, page 3754, and 1894, page 2921. Maps of the harbor accompany the Reports of 1878, 1883, 1884, 1888, 1889, 1890, and 1893.

The improvement of the harbor is now in charge of the Engineer Department, in accordance with the project adopted by the river and harbor act of July 13, 1892, providing for the diversion of the Yazoo River into Centennial Lake.

The total expenditures under the Mississippi River Commission have been $579,219.43, of which about $136,494.66 were applied at Delta Point and about $442,724.77 in Vicksburg Harbor.

LOWER YAZOO LEVEE DISTRICT (365 TO 592 MILES BELOW CAIRO).

This district extends in Mississippi from the Coahoma-Bolivar County line to the mouth of the Yazoo River, being practically coterminous with the local Mississippi levee district.

The levee line is continuous, disregarding the five crevasses made by the recent flood, from the upper end of the district to Eagle Lake. Its length is about 186 miles, covering about 215 miles of the river.

It contained on May 31, 1896, about 20,500,000 cubic yards of earth, the United States having built about 6,706,447 cubic yards. During the past year there have been added to the line about 256,153 cubic yards paid for by the United States, and about 1,418,239 cubic yards paid for by the local board. The length of line abandoned in the construction of new loops was 14,800 feet, containing about 263,146 cubic yards. Tabular statements of expenditures and work done by the United States accompany this report.

The Mississippi board of levee commissioners did work at the following localities:

Stations 2066–2590 (404 L), enlargement of levee.
Stations 2880–2959 (422 L), enlargement of levee.
Stations 3909–4168 (457 L), enlargement of levee.
Stations 4706–4884 (476 L), new loop.
Stations 0–30 (479 L), enlargement of levee.
Stations 3700–3808 (550 L), enlargement of levee.
Stations 3982–4098 (551 L), enlargement of levee.
Stations 4366–4395 (560 L), new loop.
Stations 4395–4567 (560 L), enlargement of levee.
Stations 4719–4740 (567 L), new loop.

The adopted provisional grades for levee work in this district are 5 feet above previous highest water north of Greenville, and 4 feet south of Greenville.

From June until December the operations under the General Government consisted almost entirely in care of the levees by cutting weeds, and in making surveys and estimates for proposed enlargement. The old numbering of stations, dividing the line into sections 100 feet long, had become defective on account of the loops that had been built from time to time, and a new enumeration was adopted. Every tenth station was marked by an iron pipe 1¼ inches diameter, 4 feet long, with a 6-inch flange screwed on the lower end and a cap on the upper. This pipe was sunk about 3 feet into the levee on the land side slope, so that the top of the pipe was at about the same elevation as the crown of the levee.

Allotments of $200,000 for this district and $87,500 for the Upper Tensas district from the appropriation of June 3, 1896, were made by the Mississippi River Commission on June 22. A project for the expenditure of these allotments and of the balances from former appropriations was submitted by Captain Townsend July 24. The project was approved October 16, and authority to advertise the work was granted October 26. Bids were opened November 7. The lowest bids averaged about 14¼ cents per cubic yard in the Lower Yazoo district, and about 17 cents in the Upper Tensas district. These prices were considered excessive, and authority was requested to readvertise the work, extending the time for completion of contracts from March 1 in the Upper Tensas and June 30 in the Lower Yazoo to October 1, 1897.

The work was accordingly relet November 23, the lowest bids averaging about 2 cents per cubic yard less than before in the Lower Yazoo, and 2¼ cents less in the Upper Tensas. Nineteen contracts were made for levee enlargement in the Lower Yazoo and fifteen in the Upper Tensas, aggregating about 1,519,000 and 1,189,000 cubic yards, respectively.

Work was in progress under fifteen of the contracts in the Lower Yazoo district before the high stage of water caused all construction work to be suspended about the middle of March. Operations since that time are given below in the account of the flood of 1897.

Mr. J. D. Van Meter is in local charge of the line above Greenville, Miss., and Mr. E. C. Tollinger below Greenville.

UPPER TENSAS LEVEE DISTRICT (402 TO 606 MILES BELOW CAIRO).

This district extends from the Arkansas River to a point in Louisiana opposite Warrenton, Miss. It was formed by the resolution of the Mississippi River Commission of November 13, 1896, consolidating the Upper and Middle Tensas Levee districts into one.

Disregarding the three crevasses made by the recent flood, there is a continuous levee line about 173 miles long extending from Costello's gin, on Amos Bayou, along that bayou and Cypress Creek to the Mississippi River (13 miles), and thence along the river to the lower end of the district (160 miles). The district is protected from overflow of the Arkansas River by a levee line running along that river from the vicinity of Pine Bluff to the foot of Lake Jefferson. From Pine Bluff to Red Fork this line is of comparatively weak section, built and hitherto maintained by the local authorities. From Red Fork to the foot of Lake Jefferson (12.4 miles) the line was built in 1894–1896 by the United States with the standard section of 8-foot crown and slopes of 1 on 3.

The total yardage in this district May 31, 1896, was about 21,341,108 cubic yards, the United States having built about 14,864,307 cubic yards. During the past year there have been added to the line about 530,913 cubic yards paid for by the United States, and about 124,591 cubic yards paid for by the Tensas Basin and Fifth Louisiana Levee districts. Tabular statements of expenditures and work done by the United States accompany this report.

The work by the Louisiana boards was at the following localities:

Stations 944–1080 (439 R), enlargement of levee.
Stations 1741–1781 (452 R), enlargement of levee.
Hagamon (545 R), construction of banquette.
Willow Slough, Madison Parish, drainage ditch.
Stations 4648–4667 (606 R), banquette.

The adopted grades for levee work in this district are 4 feet along Amos Bayou and Cypress Creek, 4½ feet along the Mississippi River, in Arkansas, and 5 feet in Louisiana.

The letting of contracts for levee enlargement in this district is described above in the report for the Lower Yazoo district. Work was in progress under thirteen out of the fifteen contracts before the arrival of the recent flood.

Four informal contracts were made June 12, 1896, for construction of banquettes at Salem, Villa Vista, Millikens Bend, and Reed levees, and the work completed early in November. The other operations prior to the flood consisted in caring for the line by cutting weeds and in making surveys and estimates for proposed work.

Mr. H. St. L. Coppée is in local charge of the line north of Greenville, Mr. E. C. Tollinger south of Greenville, in Arkansas, and Mr. W. S. Brown in Louisiana.

HIGH-WATER PROTECTION OF LEVEES, FLOOD OF 1897.

When the flood became imminent practically all the funds allotted for levee work were covered by existing contracts, leaving only small balances available for the protection of levees. Some materials and tools were on hand, and the plant of the district was available for distributing supplies. Arrangements were made with the local authorities for combined action, so as to make the most effective use of the means available. In the Lower Yazoo district the Government forces that were employed in connection with the contracts along the upper forty miles of the district assumed charge of the line from the Coahoma-Bolivar County line (365 L) to Mound Landing (435 L), the Mississippi levee board agreeing to guard the rest of the line south to Eagle Lake, and to pay for all labor and materials in case extensive operations should become necessary. The latter condition, however, was modified by the use of Government funds as they became available. The protection of the Arkansas River levees from Red Fork to the Lincoln County line was successfully undertaken by the Red Fork levee board.

Below Red Fork (to Lake Jefferson) the line was maintained by the Government forces. The levees along Amos Bayou, Cypress Creek, and the Mississippi River front in Arkansas were protected by the United States in conjunction with the Desha and Chicot County Levee districts of Arkansas and the Tensas Basin Levee district of Louisiana.

Below the Louisiana line the protection of the levees was at first undertaken by the Fifth Louisiana Levee district, the United States assisting with barges and boats, and furnishing some materials. As soon as money became available, however, the Government forces assumed charge of the greater portion of the line in Louisiana, as the funds of the local board were about exhausted.

The following allotments were made to the Third district for the protection of the levees:

March 18	$10,000
March 24	20,000
March 31, Lower Yazoo	45,000
March 31, Upper Tensas	40,000
Total	115,000

Active operations began about March 16, in the vicinity of Australia, at the upper end of the district, and then lower down as the flood wave advanced. The river continued to rise rapidly, at the rate of 0.6 to 0.8 feet per day, until at nearly all points in the district the flood had exceeded the highest water of former years by 2 to 3 feet.

This unprecedented stage of the river developed many weak places, and many miles of levee had to be topped up to keep above the rising water. The most strenuous efforts were put forth by all concerned. I wish in this connection to especially commend my assistants for their untiring energy and incessant devotion to the work.

The rate of rise was first checked by the breaks above, in the White River Levee district, occurring from March 22 to March 25, and the four crevasses in the Yazoo front, that occurred on March 28, 29, and 30, were sufficient to produce a falling gage that relieved the intense strain that had been felt throughout the upper half of the district.

In Louisiana the situation began to grow most critical after April 6, when the return flow from the Yazoo Basin appeared at Vicksburg. The river rose here steadily about three-tenths per day until the highest reading at Vicksburg, of 52.5, was reached, 3.5 feet above the flood of 1890, which had been the standard for levee construction along this part of the river. At this time, April 16, the Biggs crevasse (503 R.) occurred, and was followed by a stationary or slightly falling gage, that permitted the withdrawal of most of the forces along the line.

The details of the work of strengthening the levee are exhibited in a table accompanying this report. The usual methods were employed. The topping was done preferably with teams and scrapers where the condition of the land slope permitted their use; in other cases wheelbarrow forces were used. Sometimes the earth was put in sacks and carried on handbarrows or on the shoulder. In extreme cases the earth was taken from the land side in the crown of the levee itself and thrown up on the river side.

In places not exposed to wave action it was sufficient to bank up the earth alone. Where exposed, however, some revetment for the topping had to be employed. Sometimes this consisted of inch boards held vertical, or, preferably, slightly inclined to the rear, by 2 by 4 inch stakes driven several feet into the levee near the front edge of the crown. Usually this was supplemented by a row of sacks filled with earth or by a strip of burlap bagging, to prevent the loose earth from washing out under the boards. In some cases this plank revetment had to be supported by strips of wood, or, preferably, pieces of wire, running back to anchor stakes.

Sometimes the sacks were used without the planking; sometimes the bagging was used alone, being fastened in position by wooden pins. Sometimes a bulkhead was constructed consisting of two rows of planking a couple of feet apart and filled in between with earth. In nearly all cases the sod to be covered by the fresh earth was broken up by spade or plow, to secure a better bond.

It was not usually the topping, however, that caused the greatest anxiety, but rather the sloughing away of the land slope that occurred in many cases. The usual method of treating these sloughs was to place brush on them to secure better drainage, and then to weight them down with sacks of earth, forming a buttress to check further movement to the rear. As they were caused by the earth of a loamy or silty nature becoming saturated with seep water, the best method to correct their tendency to develop was to throw earth on the river slope under water and thus check the seepage. Sand boils were treated in some cases by placing bagging over them, held in position by sacks of earth. The bagging checked the flow of sand, but permitted the passage of the water. In other cases, a counter head of water was obtained by placing over the boil a barrel with open ends, or inclosing it with a mound of earth. The great value of banquettes was clearly demonstrated by the comparative immunity from evils of this sort in those portions of the line where banquettes are constructed.

There can hardly be any room for doubt that there is an extravagant use of materials, especially sacks, in a high-water fight. To a certain extent this seems unavoidable. There is a widespread belief among the people that must be employed in these operations that all efforts would be futile without a liberal supply of sacks; consequently calls for them are coming in from all quarters. It is simply impossible for the expert assistants to personally investigate all these cases at once, while an immediate response is necessary in order to keep the forces at work and have something done.

The materials expended in the Third district, in addition to nails, twine, etc., were about as follows: Nine hundred and eighty-six thousand sacks; 1,125,000 feet of lumber; 17,000 yards of bagging.

The plant of the district rendered indispensable service during the high-water fight in the distribution of supplies. At the time of the greatest activity the three steamers *Emma Etheridge*, *Vedette*, and *Meter* were in commission, and the *Thos. B. Florence* was borrowed from Major Willard at Vicksburg. Twenty-four barges and 12 quarter boats were distributed at various points throughout the district.

I can not yet give an accurate statement of the cost of the high-water operations in the Third district, but the total expenditures by the Government will be about $118,000, and it is thought that the expenditures by the local boards will aggregate about $150,000, giving a total of $268,000. The estimated cost of closing the breaks on permanent lines is about $300,000.

The yardage required to bring all levees in the Third district to a grade of 3 feet above the flood of 1897, with banquettes where needed, is estimated at about 17,000,000 cubic yards. At 15 cents per yard the cost would be about $2,550,000.

The list of crevasses in the Third district is as follows:

Crevasse.	Miles below Cairo.	Time of occurrence.
Amos Bayou	400 R	11 p. m. Mar. 25
Sledge	376 L	3 p. m. Mar. 29
Stokes	380 L	8.30 p. m. Mar. 30
Stop Landing	434 L	3 a. m. Mar. 30
Deerfield	492 L	8 p. m. Mar. 28
Shipland	548 L	Apr. 21
Biggs	603 R	10 p. m. Apr. 16
Reed	604 R	Apr. 19
Total length of breaks		

The total length of levee lines in the district is about 371 miles. breaks is eight, aggregating about 12,690 feet in length, or 0.65 of 1 entire system. The Amos Bayou crevasse was of little importance, the end of the line, around which the water was already passing quantities, estimated by Mr. Coppée at about 120,000 cubic feet per s

The Biggs break was said to have been started by the waves of a p but there had been great trouble with sloughing on other portions of

The Shipland, or Promised Land, crevasse was due to a slough cause ting mired on the levee.

The Deerfield crevasse occurred during a heavy windstorm, and caused by wave action. As far as known, the other breaks were du defects in the body of the levee. Only two of the breaks occurred ernment forces were in immediate charge—at Amos Bayou and Stop L levee officials were in charge in the neighborhood of the other break their occurrence. The breaks usually occurred at night at unsuspect men and materials were difficult to obtain, and there is reason for thin might have been prevented in some cases if they could have received energetic treatment that was successful in many other instances whe ness developed. This indicates the necessity for an efficient system jecting all portions of the line to minute inspection, especially by ni

The area overflowed in Third district is about 580 square miles i square miles in Louisiana, and 3,770 square miles in Mississippi south o Bolivar county line, giving a grand total of about 4,800 square miles.

I estimate the overflow due to crevasses at about 3,900 square m from the above total about 320 square miles in the lower end of the Y the 580 square miles in Arkansas that were inundated by water escap ends of the two levee systems.

The overflow in Arkansas was of comparatively short duration, an to have caused any special suffering or damage. At the time of this r has run off sufficiently to permit planting on the greater part of the c that had been overflowed in the Yazoo Basin.

The following table gives data concerning the crevasses and subm the Third district for several flood years:

Year.	Crevasses.			Areas
	Number.		Aggregate length.	Approxi area (squ miles)
	Right bank.	Left bank.		Right bank.
			Feet.	
1890	10	7	22,540	3,050
1891	1	2	2,022	418
1892	6	....	6,376	3,000
1893	5	....	8,562	2,670
1897	3	5	12,690	1,030

Attention is invited to the appended reports of the Assistant Engi of levees for additional details of the work.

SURVEYS, GAUGES, AND OBSERVATIONS.

Surveys were made of Carters Neck and Caulks Neck to determine the rate of caving, and complete surveys were made of the different revetments throughout the district in May and June, 1896. Special surveys were made of broken revetments at Louisiana Bend and Greenville Harbor.

Tracings and blue prints were made showing the results of these surveys.

PLANT.

Repairs to plant were made during the year as shown in the detailed statement accompanying the report of Mr. Hider.

The cost of repairs amounted to $9,358.50, and the cost of caring for the floating plant and other property amounted to $30,261.91.

The steamer *Osceola*, one pile driver, and ten barges were transferred to the officer in charge of the Fourth District in February, 1897, and four barges have been transferred this month to the secretary of the Commission.

The following papers and maps accompany this report:
Report of Mr. Hider on revetment work and plant.
Report of Mr. Coppée on levees in Arkansas above Greenville.
Report of Mr. Tollinger on levees in Arkansas and Mississippi below Greenville.
Report of Mr. Van Meter on levees in Mississippi above Greenville.
Report of Mr. Kerr on levees in Mississippi below Greenville.
Table of operations for high-water protection of levees.
Table of revetment work in Third District.
Tabulated labor statements of levee work.
Tables of expenditures by United States for levees.
Map of Third District.
Map of overflowed lands, Third District.
High-water slopes of the Lower Yazoo and Upper Tensas districts.

The financial statement, list of civilian employees, and abstracts of proposals will be forwarded on or about July 1.

Very respectfully, your obedient servant,

H. C. NEWCOMER,
First Lieut., Corps of Engineers.

Col. G. L. GILLESPIE,
Corps of Engineers,
President Mississippi River Commission.

REPORT OF MR. ARTHUR HIDER, ASSISTANT ENGINEER.

GREENVILLE, MISS., *May 15, 1897.*

SIR: The following annual report of construction work, repairs, care of plant, and surveys from May 1, 1896, to May 1, 1897, is respectfully submitted:

REVETMENTS.

No new revetments were built during the year, the work of construction being confined to repairing defects which developed in the Greenville Harbor and Louisiana Bend revetments during the high water.

REPAIRS TO GREENVILLE HARBOR REVETMENT.

After the high water of April, 1896, had subsided to a bank-full stage, a defect showed itself in the revetment constructed in 1891 between ranges 53 and 56. This, as the river fell, developed into a pocket or cave in the upper bank revetment of considerable size. Soundings showed that there had been a very considerable scour under the subaqueous mat in front. This scour seems to have been induced by the proximity of the old spur dike constructed in 1887 to the present revetted bank, allowing only a narrow channel between it and the shore.

To remedy the defect in this revetment a mattress 677 feet long and 300 feet wide was constructed, well overlapping the mat below, which it was found necessary to build in 1894 to remedy a like defect in the original revetment, due to a similar cause.

The mat constructed was of the standard fascine type, and the grading and paving of the slope was done in the usual manner.

The repairs were made between ranges 49 and 57. Work was begun on October 21, 1896, with a small force, cleaning away drift and stripping the stone from the broken upper slope preparatory to regrading. Part of the stone was loaded on a barge, and the rest moved beyond the limits of the new slope, to be used for repaving.

Quantity of stone removed, 519 cubic yards.

GRADING.

Hydraulic grader No. 1 began operations on October 27, 1896, and finished regrading the upper slope on November 5. Total length of bank graded, 455 linear feet, an average of 50½ linear feet per day.

MATTRESS CONSTRUCTION.

The plant was assembled in place on November 6 and the work of mat building began on the 7th. A mat 677 feet long and 300 feet wide was finished and sunk in place on the 21st. This was connected with the graded bank by a shore mat 300 feet long with an average width of 101 feet.

Number squares mattress built	2,031.0
Number squares pocket mat built	303.5
Total	2,334.5

In sinking the river mat an unexpected fault developed. A strip of fascines about 40 feet wide, extending from the outer edge of the mat in toward the shore for about half the width of the mat, became detached from the main body, dumped its ballast, and floated to the surface. This break occurred about 200 feet below the head of the mat, which at the time was resting on the bottom, and as the lower part of the mat sank in place without any perceptible movement downstream, it would seem that the fault was due to the parting and unraveling of the sewing wires which bind the fascines to the bottom longitudinal cables. To avoid a repetition of this in the future, which may happen when mats are sunk in strong eddy currents, it was suggested that drop wires be put in at frequent intervals, connecting the upper and lower cables and giving an additional fastening between the fascines and longitudinal cables at these points.

UPPER BANK PAVEMENT.

The stone was laid on the graded slope from 8 to 6 inches in thickness and the spaces filled in with spalls in the usual manner, so as to make a compact covering.

Number of squares paving	527.5
Number of cubic yards per square	2.94

MATERIALS.

Brush and poles were obtained by contract from Hunter & Frey; stone from the reserve on the barges at the fleet in Greenville.

TOWING.

The towing of material was done by the U. S. steamer *Emma Etheridge* with a single crew. The tug *Parker* was used for moving material and barges when required. The work of repairs was finished on November 30, and the party and outfit transferred to Louisiana Bend, to begin the repairs at that point.

Classification of work.

Channel mat (1) 300 by 677 feet	squares	2,031
Pocket mat (fascine type)	do	303.5
Shore connection (woven type)	do	127.8
Bank grading, hydraulic (stations 52 to 56+55)	linear feet	455
Bank grading, hand (stations 50 to 51+50)	do	150
Bank paving	squares	527.5
Stone loaded (stripped from bank)	cubic yards	519

Distribution of material.

[Channel mat 300 by 677 feet=2,031 squares.]

Material.		Quantity.	Per square.
Brush used	cords	2,962.5	1.44
Poles used	do	114.6	.056
Stone used	cubic yards	2,235.8	1.10
Cable, ⅝-inch strand	pounds	2,100	1.03
Wire strand, $\frac{5}{16}$ inch	do	6,118	3.01
Wire strand, ⅜ inch	do	10,212	5.028
Galvanized wire No. 12	do	4,068	2
Silicon-bronze wire	do	2,585	1.27
Magnolia clips	number	2,646	1.3
Spikes	pounds	280	.14
Staples	do	393	.19
Cable clamps	number	150	.07

Distribution of material—Continued.

[Pocket mat (fascine type). 303.5 squares.]

Brush	cords	454.1	1.16
Poles	do	18	.059
Stone	cubic yards	414.7	1.36
Wire strand, 5/16-inch	pounds	913	3.01
Wire strand, ½-inch	do	1,526	5.028
Galvanized wire, No. 12	do	607	2.00
Silicon bronze wire	do	385	1.27
Magnolia clips	number	394	1.30
Staples	pounds	57	.19

[Shore connection (woven). 127.8 squares.]

Brush	cords	128	1.00
Poles	do	18	.14
Stone (stripped from bank)	cubic yards	192	1.5
No. 12 galvanized wire	pounds	725	5.66

[Bank paving. 527.5 squares.]

Stone	cubic yards	a 1,554	2.94

a Of this, 327 cubic yards stripped from old bank work and previously expended.

Material used per linear foot of channel mattress.

Stone	cubic yards	3.30
Brush	cords	4.38
Poles	do	.17
Wire strand, ⅜-inch	pounds	3.10
Wire strand, 5/16-inch	do	9.03
Wire strand, ½-inch	do	15.09
Galvanized wire, No. 12	do	6.01
Silicon bronze wire	do	3.83
Staples	do	.58
Magnolia clips	number	3.91
Spikes	pounds	.38
Cable clamps	number	.22

Material expended per linear foot of completed work.

[677 linear feet.]

Material.		Quantity.	Average per linear foot.
Brush	cords	3,544.5	5.23
Poles	do	150.8	.22
Stone	cubic yards	4,396	6.49
Wire strand, ⅜-inch	pounds	2,100	3.10
Cable, 5/16-inch	do	7,031	10.39
Wire strand, ½-inch	do	11,738	17.33
Galvanized wire, No. 12	do	5,400	7.97
Silicon bronze wire	do	2,980	4.40
Magnolia clips	number	3,040	4.49
Clamps, cable	do	150	.22
Spikes	pounds	260	.38
Staples	do	450	.66

Percentage of cost of the different items of work.

Item.	Charge.	Per cent.
Pay roll	$5,576.75	33.384
Subsistence	961.24	5.763
Materials	9,621.86	57.602
Property and miscellaneous	544.32	3.251
Total	16,704.17	100

Percentage of cost of the several different kinds of work.

Kind of work.	Charge.	Per cent.
Hydraulic grading	$408.78	2.450
Hand grading	328.93	1.970
Channel mat	9,908.21	59.365
Pocket mat	1,425.37	8.532
Shore connection	256.29	1.534
Loading stone	489.11	2.928
Paving bank	2,166.37	12.969
Towing	1,260.35	7.545
Property and miscellaneous	460.76	2.758
Total	16,704.17	100

Cost per unit of work done.

Classification.	Pay roll.	Subsistence.	Material.	Total.	Unit cost labor.	Unit cost material.	Total per unit.
Mattress (2,031 squares)	$2,825.21	$448.90	$6,634.10	$9,908.21	$1.6125	$3.266	$4.8785
Hydraulic grading (455 linear feet)	241.48	43.97	123.33	408.78	.6273	.271	.898
Hand grading (150 linear feet)	283.70	45.23	....	328.93	2.192	....	2.192
Pocket mat (303.5 squares)	285.25	45.38	1,094.74	1,425.37	1.09	3.604	4.694
Shore connection (127.8 squares)	70.00	11.14	175.15	256.29	.634	1.37	2.0069
Unloading stone (519 cubic yards)	421.97	67.14	....	489.11	.931	....	.931
Paving bank (527.5 squares)	728.10	115.84	1,322.43	2,166.37	1.601	2.509	4.11
Property and miscellaneous	....	....	....	460.76	....	....	....
Towing	721.04	183.64	855.67	1,260.35	....	....	....
Total	5,576.75	961.24	9,705.42	16,704.17	....	....	....

Work done, 677 linear feet. Cost per linear foot, completed work, $24.675.

REPAIRS TO LOUISIANA BEND REVETMENT.

A survey over this revetment made in September showed that between ranges 95 and 99 there had been a slip or sinking down of the upper bank of from 4 to 6 feet. As there was no evidence of settlement of the subaqueous revetment in front, and this point is located above where the current at high stages impinges against the bank, nothing in the way of repairs was done. The defect will probably cure itself the first high water, as it is immediately below the mouth of Old River, which is gradually silting up.

From ranges 125 to 127 the bank had caved to such an extent as to entirely destroy the upper bank paving. At this point the bank was regraded by hand and repaved, and a mat 484 feet long by 300 feet wide sunk, so as to well cover the injured part of the revetment.

Below range 156 to the end of the bank originally protected by revetment, a distance of about 1,200 feet, the active caving in the bend below the revetment which had been in progress since the work was finished in 1892, had worked upstream so as to undermine and practically destroy this part of the work.

A mattress 763 feet long by 300 feet wide was constructed to hold the end of the revetment in its present position, if possible, and prevent further damage.

The bank here is comparatively low and the high stage of water at the time prevented the lower 100 feet of the slope being made as flat as desirable.

The plant arrived December 2, 1896, and repairs were finished January 14, 1897, a total length of 1,247 feet of work completed, less 352 linear feet of upper bank paving which needed no repairs.

GRADING.

At the lower end of the work before grading could be begun it was necessary to clear the bank of an extensive accumulation of drift and a dense undergrowth of brush and small trees. Space cleared, 675 feet by 100 feet. Grading of this portion of the bank was begun December 5. The hydraulic grader worked until December 18, when work was discontinued to allow mat construction to proceed. Work was resumed on January 4 and the grade completed except the lower 100 feet on January

11. Total working time, nineteen days. Length of bank graded, 645 feet. Length per day, 34 linear feet. Two hundred and two linear feet was graded by hand between ranges 124 and 128.

MATTRESS CONSTRUCTION.

The usual type of fascine mattress was built, extra top cables being used near the outside edge for additional strength.

Connection was made between the top and bottom cables by passing a $\frac{3}{8}$-inch wire strand around each cable encircling one fascine; the two ends of the fastening were tied with a square knot and then drawn taut by blocks and clamped to both top and bottom cables.

The extra strength was given, as the water was 97 feet deep with a swift current—6 feet per second—along the outside.

Number squares mattress built	13,741
Number squares pocket mattress built	250
Total	13,991

UPPER BANK PAVEMENT.

The paving of the upper slope was made entirely of quarry spawls laid to a depth of 10 inches.

Number of squares paving	903.9
Number cubic yards per square	2.77

Brush and poles were obtained by contract from Hunter & Frey. Stone was obtained from the reserve at the fleet at Greenville, and from the reserve on the bank at Pilchers Point, which was loaded on barges.

	Cubic yards.
Quantity received from Greenville	2,072
Quantity loaded on barges	3,576.6
Total	5,648.6

TOWING.

The towing was done by the district steamer *Emma Etheridge*. The last of the plant was returned to Greenville January 20.

These repairs were under the immediate charge of Mr. George C. Thomas as superintendent of construction.

Channel mats (2), 484 by 300 feet; 763 by 300 feet; total, 1,247 by 300 feet	squares	3,741
Pocket mats (2)	do	250.7
Bank cleared (100 by 675)	do	675
Bank graded (hydraulic) (Stations 157+18 to 163+63)	linear feet	645
Bank graded (hand) (Stations 124+58 to 126+60)	do	202
Bank paved	squares	903.9
Stone loaded (includes 225 cubic yards from bank)	cubic yards	3,801.6

Distribution of material.

[Channel mat (1,247 by 300 feet). 3,741 squares.]

Material.		Quantity.	Per square.
Brush	cords	6,307	1.686
Poles	do	204.3	.054
Stone	cubic yards	3,118.5	.83
Cable, $\frac{9}{16}$-inch	pounds	9,906	2.65
Wire strand, $\frac{3}{8}$-inch	do	3,100	.83
Wire strand, $\frac{5}{16}$-inch	do	22,483	6.01
Wire strand, $\frac{1}{4}$-inch	do	19,079	5.10
Galvanized wire, No. 12	do	4,788	1.28
Silicon bronze wire	do	4,080	1.09
Staples	do	561	.15
Spikes	do	140	.04
Clips, magnolia	number	3,030	.81
Clamps, cable	do	450	.12

Distribution of material—Continued.

[Pocket mat (fascine type). 250.7 squares.]

Brush ....cords..	426.3	1.086
Stone ....cubic yards..	235	.94
Wire strand, $\frac{5}{16}$-inch ....pounds..	1,517	6.05
Wire strand, $\frac{1}{4}$-inch ....do....	1,298	5.10
Wire, No. 12 ....do....	312	1.28
Silicon bronze wire........do....	268	1.07
Staples ....do....	38	.15
Clips, magnolia ....number..	208	.83

[Paving bank. 903.9 squares.]

Stone ....cubic yards..	2,520.1	2.77

Material used per linear foot of channel mat.

Brush ....cords..	5.05
Poles........do....	.16
Stone ....cubic yards..	2.50
Wire strand, $\frac{9}{16}$-inch ....pounds..	7.94
Wire strand, $\frac{3}{8}$-inch........do....	2.50
Wire strand, $\frac{5}{16}$-inch........do....	18.03
Wire strand, $\frac{1}{4}$-inch........do....	15.30
Staples........do....	.45
Spikes ....do....	.11
Clips, magnolia........number..	2.43
Clamps, cable ....do....	.36

Material used per linear foot of completed work.

Material.	Quantity.	Per linear foot.
Brush........cords..	6,733.3	5.40
Poles........do....	204.3	.16
Stone........cubic yards..	5,643.6	4.52
Wire strand, $\frac{3}{8}$-inch ....pounds..	2,100	2.50
Wire strand, $\frac{9}{16}$-inch ....do....	9,906	7.94
Wire strand, $\frac{1}{4}$-inch ....do....	20,377	16.34
Wire strand, $\frac{5}{16}$-inch ....do....	24,000	19.24
Wire, No. 12........do....	5,100	4.09
Wire, silicon bronze........do....	4,368	3.50
Staples........do....	600	.48
Spikes........do....	140	.11
Clips, magnolia ....number..	3,258	2.61
Clamps, cable ....do....	450	.36

Percentage of cost of the various items.

Items.	Charge.	Per cent.
Pay roll........	$9,363.94	31.973
Subsistence........	1,989.68	6.794
Material	17,774.19	60.690
Sundries........	60.94	.208
Property........	98.00	.335
Total	29,286.75	100

Percentage of cost of the different kinds of work.

Classification.	Pay roll.	Subsistence.	Materials.	Total.	Per cent.
Channel mat	$3,920.98	$898.95	$18,362.56	$18,182.49	62.084
Pocket mat	181.75	41.66	892.66	1,116.07	3.811
Clearing	43.20	9.93	....	53.13	.181
Hand grading	874.84	200.42	....	1,075.20	3.637
Bank paved	1,524.90	349.33	2,530.55	4,404.78	15.006
Loading stone	868.94	199.16	....	1,068.10	3.646
Hydraulic grading	752.00	43.29	291.55	1,086.84	3.720
Towing	1,197.89	246.84	696.97	2,141.20	7.310
Sundries	....	....	....	60.94	.271
Property	....	....	....	98.00	.334
Total	9,363.94	1,989.58	17,774.29	29,286.75	100

Cost per unit of the various kinds of work.

Classification.	Pay roll.	Subsistence.	Materials.	Total.	Unit cost labor.	Unit cost materials.	Total per unit.
Channel mattress (3,741 squares)	$3,920.98	$898.95	$13,362.56	$18,182.49	$1.29	$3.571	$4.86
Pocket mattress (250.7 squares)	181.75	41.66	892.66	1,116.07	.89	3.56	4.451
Clearing (675 squares)	43.20	9.93	....	53.13	.7871	....	.7871
Hand grading (202 linear feet)	874.78	200.42	....	1,075.20	5.323	....	5.323
Bank paved (903.9 squares)	1,524.90	349.33	2,530.55	4,404.78	2.072	2.7893	4.8703
Loading stone (3,801 cubic yards)	868.94	199.16	....	1,068.10	.2783	....	.2783
Hydraulic grading (645 squares)	752.00	43.29	291.55	1,086.84	1.233	.4321	1.6851
Towing	1,197.89	246.84	696.97	2,141.20	....	....	....
Sundries	....	....	....	60.94	....	....	....
Property	....	....	....	98.00	....	....	....
Total	9,363.94	1,989.58	17,774.29	29,286.75	....	....	....

Length of completed work, 1,247 linear feet. Total cost of work, $29,286.75. Cost per linear foot completed work, $23.4858.

PRESENT CONDITION OF REVETMENT.

The present high stage of water, which is now from 5 to 8 feet over the natural banks, renders it impossible to give any reliable information in regard to the present condition of the different revetments, as under present circumstances no accurate examination can be made.

On April 6, attention was called to a break in the upper bank revetment in Greenville Harbor, about range 25, by the settling down of a large elm tree which was growing on the edge of the bank. The tree was in an exposed position, the water about 10 feet deep with a very swift current, the action of which, it is supposed, undermined the roots of the tree, causing a break in the revetment. This has enlarged by eddy action until now the broken part of the upper revetment is approximately about 300 feet in length. As this is located immediately in front of the upper part of the city of Greenville and within 275 feet of the main levee, it is urgent, both for the protection of the line of revetment itself, as well as the levee, that thorough repairs be made the next low water.

SURVEYS.

Field work.—Special surveys have been made across Carters Neck and Caulks Neck to determine rate of caving; also, complete surveys over all the revetments in the district, viz: Bolivar, Ashbrook Neck, Greenville Harbor, Louisiana Bend, Lake Providence, and Delta Point, besides special surveys over the broken revetments at Greenville Harbor and Louisiana Bend. These surveys have all been reduced, platted, and maps and blue prints made.

A copy of the levee profiles, Lower Yazoo district, was made, and tracing of charts, third district, showing changes in levee location.

All field notes have been indexed and field sheets completed to date. The party was disbanded, except the office force, on June 27. Chas. H. Miller, chief of party, was furloughed on November 6.

* * * * * * *

PLANT.

Below is given in detail a statement showing the repairs made and cost during the year. This cost includes all charges for material and labor, in subsistence of employees.

Extensive repairs will be required on all three of the steamboats to keep anything like serviceable condition.

I would respectfully renew the recommendation made the last two years construction of a new towboat, as the time is rapidly approaching, if it already arrived, when economical repairs can no longer be made to the bo in the district.

Cost of repairs to plant, third district, improving Mississippi River, May 1, 1896, 1, 1897.

Number or name.	Cost.	Remarks.
Steamer—		
Emma Etheridge	$664.64	New iron plates on cylinder timbers, new rudder new furnace liners and door shields put in; call light water; ordinary repairs during the year.
Osceola	868.00	New cylinder head, new pitman, two sets of brass up; calked above light water; ordinary repairs d year.
Vidalia	223.94	Ordinary repairs to machinery during the year.
Vedette	620.76	Cylinder timbers and wheel repaired; hole patche boiler and deck guards repaired; calked above li new valves in doctor pump; ordinary repairs d year.
Meter	192.36	New kevel bed and kevel; calked above light wa nary repairs during the year.
Tug Parker	1,351.47	Docked; new stern-post and stern; new wheel put o and painted; machinery lined up; ordinary repai the year.
Grader—		
No. 1	166.63	Feed pump bored out; ordinary repairs made to n during the season; calked above light water.
No. 3	13.60	Machinery cleaned up and oiled.
No. 77	22.02	Calked above light water.
Dredge Menge	17.00	Machinery cleaned and oiled.
Mattress boat—		
No. 26	41.50	Calked above light water; ordinary repairs during
No. 27	33.55	Do.
No. 32	25.00	Do.
No. 33	16.89	Do.
No. 188	16.13	Do.
No. 192	20.49	Do.
Quarter boat—		
No. 16	13.00	Ordinary repairs during the year.
No. 17	5.96	Do.
No. 19	68.44	New screen doors and windows made and put up; repairs during the year.
No. 31	81.13	Calked above light water; machinery on fire pu hauled; repairs during the year.
No. 38	42.56	Calked above light water.
No. 87	10.77	Do.
No. 154	11.37	Do.
No. 155	31.21	Calked above light water; repairs during the year.
No. 156	58.91	Do.
No. 158	174.60	Calked above light water; roof repaired.
No. 159	6.49	Calked above light water.
Model barge—		
Apache	25.66	Do.
Cheyenne	20.98	Do.
Comanche	22.20	Do.
Maricopa	13.37	Do.
Piute	62.09	Do.
Shoshone	23.29	Do.
Uintah	5.28	Do.
Square barge—		
No. 79	16.72	Do.
No. 80	34.79	Do.
No. 82	7.01	Do.
No. 83	19.83	Do.
No. 84	12.50	Do.
No. 85	29.45	Do.
No. 135	25.63	Do.
No. 136	25.12	Do.
No. 138	461.31	Calked above light water; cabin of store boat moved fitted up as boat, "Store."
No. 541	48.26	Calked above light water.
No. 542	13.70	Do.
No. 545	56.88	Do.
No. 546	44.69	Do.
No. 547	53.85	Do.

Cost of repairs to plant, third district, improving Mississippi River, etc.—Continued.

Number or name.	Cost.	Remarks.
Square barge—Continued.		
No. 548	4.00	Calked above light water.
No. 549	27.86	Do.
No. 550	37.09	Do.
No. 551	31.76	Do.
No. 553	44.57	Do.
No. 556	26.96	Do.
No. 557	40.88	Do.
No. 558	37.00	Do.
No. 561	45.76	Do.
No. 562	113.67	Docked; repaired hole in bottom; spliced broken gunwale; calked above light water.
No. 563	44.73	Calked above light water.
No. 564	111.26	Docked; hole in rake repaired; calked.
No. 204	21.53	Calked above light water.
No. 205	32.17	Do.
No. 210	16.11	Do.
No. 216	11.90	Do.
No. 219	29.42	Do.
No. 220	19.88	Do.
No. 224	30.59	Do.
No. 225	48.56	Do.
No. 226	162.20	Sheathing deck; sides and rakes calked above light water.
Fuel barge A	28.44	Calked above light water.
Fuel barge E	19.67	Do.
Fuel barge F	1.75	Do.
Machine shop No. 222	93.89	Sides and rakes calked; ordinary repairs to machinery during year.
Carpenter shop No. 78	112.24	New timberheads; sides and rakes calked; ordinary repairs to machinery during the year.
Pile driver—		
No. 32	15.18	Calked above light water.
No. 33	173.03	Leads, cabin, and boiler room repaired; machinery overhauled.
No. 49	1,008.39	Docked; new lower gunwales; new streamers and under parts of bulkhead; new bottom and rakes; machinery thoroughly overhauled.
No. 54	6.80	Sheathing sides and rakes.
Dump scow No. 2	7.54	Calked above light water.
Dry dock	40.48	New packing made for 11-inch rotary pump; new piston for feed pump; 12 boiler flues expanded.
Pontoon dock	2.64	Calked above light water.
Skiffs	28.68	General repairs to 8 skiffs during the year.
Pumps	251.74	Ordinary repairs during the year.
Coal boxes	33.75	Do.
Property (kitchen outfit)	285.88	Do.
Target rods	5.90	Do.
Stages	94.68	Do.
Bench marks, levees	78.22	Do.
Surveys	7.87	Do.
Greenville Harbor improvement.	220.05	1,500 clevises made; repairs to tools, etc., during working season.
Louisiana Bend improvement.	82.75	
Total	9,358.50	

Approximate value of plant belonging to the United States and used in the third district, improving Mississippi River, May 1, 1896, to April 30, 1897.

Class of property.	No.	Approximate value.	Class of property.	No.	Approximate value.
Steamer Etheridge	1	$5,184	Floating dry dock	1	$12,810
Steamer Vedette	1	2,592	Floating pontoon dock	2	450
Steamer Meter	1	2,144	Floating stern dock	1	200
Tug Parker	1	3,240	Pile driver and outfit	3	2,000
Mat boats 26 and 27	2	8,100	Skiffs	14	153
Mat boats, old	4	90	Dredge Menge	1	10,000
Head quarter boat	1	5,000	Dump scow No. 2	1	500
Quarter boats and outfit	14	22,389	Calking flats	3	90
Store boat	1	1,000	Tools and appliances		800
Hydraulic grader	2	12,900	Office furniture and safe		250
Hydraulic grader (small)	1	810	Surveying instruments		2,000
Model barges	9	450	Machine shop and outfit	1	4,500
Square barges	11	24,948	Carpenter shop and outfit	1	3,240
Do	21	23,600			
Square barges (old)	10	500	Total	108	150,000

The cost for twelve months of caring for the above floating plant, property, and outfit thereon, was $30,261.91.

The average number of employees engaged in this service was 40.

The average daily cost of subsistence for employees engaged in superintendence and repair of plant, was $0.319.

Very respectfully,

ARTHUR HIDER,
United States Assistant Engineer.

First Lieut. H. C. NEWCOMER,
Corps of Engineers, U. S. A.

REPORT OF MR. H. ST. L. COPPÉE, ASSISTANT ENGINEER.

GREENVILLE, MISS., *May 15, 1897.*

SIR: I have the honor to submit the following report of operations in the Upper Tensas Levee district above Greenville during the year ending May 15, 1897:

The Upper Tensas district above Greenville comprises the levees from Red Fork, on the right bank of the Arkansas River, to the lower end of Lake Jefferson, and from high land on Amos Bayou at Costello's Gin to Columbia, Chicot County (469 R), a distance in all of about 57 miles. From Costello's Gin to Lake Jefferson is unprotected.

The Arkansas River levees to their present southern terminus were completed prior to the time when the last annual report was submitted, and no further construction work has been undertaken. From Red Fork to the lower end of Lake Jefferson the levee was built for the purpose of lessening the amount of water passing at flood stage between the two systems, by lowering the head under which the water entered the intervening basin. The elevation of the natural surface of the land at Costello's Gin is 160, Memphis datum, and the water surface of the recent flood at lower end of Red Fork line is practically 166, Memphis datum.

River conditions.—The changes in position of the bank lines throughout the district have not been very pronounced except at one or two points. At Station 337 of the Red Fork line until July, 1896, the bank caved, but since that date no change has taken place. The river distance is 375 feet. At Lucca, and for some distance above and below, the river continues to creep toward the levee, but is still about 900 feet distant at the nearest point. There has been little or no change on the Middle Place and the Chicot fronts; also, no change on the Arkansas City front.

At Gaines Landing, when the water reached the top of the bank the caving became very active, but ceased during the flood stage. The river distance is now over 1,000 feet. Also, near the upper end of the Panther Forest short line the caving in the bend was considerable, but did not reach the old front levee before being checked at the flood stage. The left-hand channel between Linwood and Luna has probably increased very considerably in depth and importance during the high water. This opinion is based on information derived from pilots and other river men, as well as personal observation.

CONSTRUCTION.

When the last annual report was submitted, a banquette was under construction just north of Arkansas City, which was completed August 20, 1896.

In October a survey of the main line and Amos Bayou was made, and from accurate height and slopes thus obtained estimates were submitted on which were based the contracts for enlargement, let November 23, 1896, which are now partly completed, as shown in the accompanying statement.

The profile plotted from the October survey notes showed the portion of the line from stations 1740 to 1780, Panther Forest short line, quite low, due to the sinking or the compression of the foundation. An informal contract was made for topping this line, and only partly completed before the high water. From stations 1830 to 1904 was also found to be low, but not topped, as it was considered practicable to maintain it during high water with temporary expedients. It was held, but with great difficulty, and at considerable expense, owing to the fact that it shrank while the water was against it.

The levee from stations 945 to 1020, known as the railroad enlargement, was reenlarged during the year by the Tensas Basin Levee board to a grade 5 feet above the high water of 1893, and the Fulton Lake line, stations 1020 to 1080, is now under contract and partly completed by the same board to the same grade (see tabulated statement).

The approximate yardage in the subdistrict is as follows:

	Cubic yards.
Material in Red Fork levees, May, 1896	588,333
Material in levees, Costello's Gin to Columbia, less 6,000 cubic yards, Amos Bayou break	5,994,000
Material added by Government during flood	98,271
Material added by Tensas Levee board during flood	94,679
Total material in entire line, May, 1897	6,775,283

NEW WORK.

The grade adopted before the flood of 1897 was 4 feet above the previous high water for all levees above Lucca Landing (427 R), and 4½ feet above the same, south of that locality.

During the high water just past the flood surface reached an elevation throughout the main line of from 1½ to 2½ feet above the water of 1893.

General repairs, weed cutting, and slashing.—The continued weed cutting and repairs to the levee slopes from year to year have greatly improved the condition of the levees. Each year the expense incurred for that purpose becomes less. The sod becomes more compact, the weeds thrive very poorly, and the rain-wash is more nearly controlled or prevented. One cutting a year is all that is necessary during a dry season. The cost of the work per station during the last season was:

	Cents.
Red Fork Levee, weed cutting, per station	24
Main line:	
Stations 0 to 1250, per station	30
Stations 1250 to 2097, per station	35

Much of the last line had wide banquette and very heavy growth of grass, with some weeds.

Slashing, Stations 1033 to 1253, per station	$1.00

The timber in this last mentioned reach was quite heavy, particularly on the land side, the trees shading the levee, thus preventing the healthy growth of grass; hence the necessity for slashing, which was accomplished at a very small cost.

Levee laws.—The local authorities fail to enforce the local laws. Hogs continue to destroy the slopes, necessitating much expense and trouble that might be avoided by a slight display of public spirit on the part of the inhabitants protected by the levee, and their officials.

HIGH WATER OF 1897.

Early in March it became apparent that very high water would obtain in the lower Mississippi some time during the spring. By the middle of March two distinct floods had passed or were passing from the Ohio Valley. About the 14th the water was in the neighborhood of 49 feet on the Cairo gage and rising, and the conditions throughout the Lower Mississippi and Ohio valleys were favorable for continued rainfall. Slight waves had come from St. Louis and the Arkansas River, helping to swell the river, which had as yet only reached 43 feet at Arkansas City. Preparations were made, should the river reach a 48-foot stage and rising, to subdivide the district into five divisions, as follows:

	Miles.
Red Fork Levee	12
Amos Bayou and main line to Station 180	8½
Main line, Stations 180-600	8
Stations 600-1510	17
Stations 1510-2097	11½

With the exception of the first, which was placed in charge of Mr. B. Baumgarden, they were superintended by the assistants employed on construction, Messrs. Geo. Elder, A. M. Todd, T. S. Shields, and Edwyl Llewellyn, respectively.

After the danger line was passed, barges with tools, sacks, bagging, lumber, and nails were placed at intervals, one for each division (except Red Fork), and as the force employed became more experienced, foremen were added at shorter intervals where the condition of the levee required more constant attention.

The contractors' outfits located at Amos Bayou, Fulton Lake, and Panther Forest proved a great assistance in the early portion of the high-water work. Two small quarter boats without outfits were used for housing the men, one at Lucca Landing and one at Fulton Lake below Arkansas City.

From the 48-foot stage (Arkansas City gage), March 21, the river rose rapidly seven-tenths of a foot per day for nearly a week, then at the rate of from three to five-tenths per day until March 29, when it reached 51.9, or 1.7 feet above the high water of 1893. From that time, owing to breaks in the Mississippi levees, five in number, it has continued to fall to the present time. As soon as it became a foregone conclusion that very high water would be experienced, all the available teams were obtained and the low portions of the line were topped, the cost being less than 20 cents per yard. As the water became higher and began to lap the crown of the levee, seep water and the softening of the toe of the slope and adjacent ground necessitated the abandonment of teams and the resort to sacks filled with earth, in many places the material to fill them being obtained from the back edge of the crown of the levee.

On the 25th of March a break occurred in the Amos Bayou line, a small levee in very bad repair, built by the Tensas Levee board in 1894. This levee had not been repaired or maintained by the Government since its construction. The break became 731 feet long, but was controlled by spur dikes. It discharged about 11,000 cubic feet of water per second. It caused no lowering of the flood in the river, and but little additional increase in the back water. The incidents relating to this break, discharge, dimensions, etc., were submitted with report May 1, 1897.

By the 27th of March, when the water had reached nearly the highest stage and was rising over a fourth of a foot per day, and seepage and tendency to slough at many points were very active, every available man in the neighboring country was employed.

In addition, a large force was obtained from Little Rock, Portland, and Munroe for the upper end of the line, and from Lake Village, Yellow Bayou, and Macon Lake for the lower end, and the fight against the water carried on day and night with great vigor and determination by superintendents, foremen, and laborers, everyone working as if impelled by the natural instinct of self-preservation, recognizing the danger, but also the possibility of maintaining the line by constant and well-directed effort. Every available skiff was pressed into service. The officers of the Missouri Pacific Railroad cooperated during the most trying time in a most valuable way, by transporting labor free of charge, furnishing a train for moving material, discontinuing important trains where roadbed was in dangerous proximity to insecure levee, etc.

The members of the Tensas Basin and Chicot Levee boards tendered their services and acted as foremen and guards day and night. The Desha Levee board procured the services of an experienced foreman and had the line in the immediate front of Arkansas City bulkheaded and sacked. One or two dangerous breaks developed in this work, but were controlled by timely assistance from the Government employees.

The line above Red Fork was successfully held, though the water was above the crown of the levee at many points, by an organization under the control of Mr. G. E. Buck, secretary of the Red Fork Levee board.

The condition of the line in the district the day before the first break occurred in the Mississippi side, which caused relief at once, and the disbanding and discharge of the greater portion of the working force, was as follows:

Above Red Fork the water was above the crown of the levee for about 3 miles, and the levee being raised by sacks by the local authorities. Of the line below Red Fork, 5 miles of the Government levee were well above the water, 7 miles very low, and of the latter, 4 miles topped with a small ridge of earth to prevent the water from washing over the crown. At the lower end two dikes of piling and sacks prevented the levee from being washed away. At the upper end of the Amos Bayou a revetment protected the end of the levee. A break existed at Station 140, then about 600 feet wide. The rest of the line, though very weak, was above the water to main line.

The main line from Stations 0 to 350 was well above the water, with the exception of Brooks Field loop (Stations 34 to 43), and giving little or no trouble except the Sains Field, which leaked very badly owing to quicksand in the foundation; thence to Station 600 the levee was, for nearly 3 miles, being raised with sacks and lumber. A large force was working day and night to keep above the water.

From Station 600 to Arkansas City about a half mile of low levee was being raised and strengthened. Many seep holes and sloughs were developing as the pressure increased, requiring the constant attention of a large force. From Fulton Lake, Station 1040, to Eunice, Station 1240, almost a continuous line, over 3 miles in length, was being raised, and a number of dangerous sloughs were being sacked.

The new levee (1894), from Stations 1240 to 1500, was well above the water and, with the exception of a few sloughs and seep holes, was giving little trouble. Thence to Panther Forest short line, Station 1730, another almost continuous line of levee, with the exception of the recently completed enlargement, was being raised (about 3 miles).

The short line to Station 1826 was being reenforced behind at one or two points with timber and sacks; otherwise it was safe, and generally well above the water; thence to the end of the line was covered with men raising the crown, bracing the dangerous sloughs, notably Carmichael, and revetting against wave-wash, principally on the Bellvue and Luna front. From one end of the line to the other the topping averaged 8 inches above the water, and was being raised as rapidly as possible, each tenth of rise in the river developing an increased line to be worked on.

A complete, thoroughly organized, and disciplined force of guards was employed on the entire line day and night, with orders to kill cattle and keep all strangers off the levee. They patrolled the line at intervals of from a half to one mile until after April 1.

On the evening of March 28, an east wind, accompanied by rain, commenced to blow with force and velocity. During the night it continued, increasing in violence, and necessitating much work on the low, exposed levee, to prevent destructive wave-wash. With the water at the extreme height, far above the crown of the levee in many places, it seemed almost a hopeless task to contend with the river.

All night long, from Amos Bayou to Columbia, large numbers of men combated with the power of the waves, the softening influence of the rain, and the constantly increasing hydrostatic pressure, but by morning the influence of each of these destructive forces was materially lessened, owing to the first break in the levees, and the crest of the flood had passed. Most of the force was at once discharged, but the continued active seepage, sloughing, and danger from cattle necessitated the employment of a considerable number of men for many days. The methods adopted in overcoming seepage, sloughs, and wave-wash, etc., were the same as have been employed for many years.

* * * * * * *

CYPRESS CREEK OUTLET.

The present high water gives valuable data upon which to base plans for preventing the discharge through the unprotected country between the Arkansas River and the Mississippi River levees. It was expected that the water would back up along the levee from Boggy Bayou Crossing to Costello's Gin, but such was not the case. It was forced up Cypress Creek to beyond the gin and flowed down along Amos Bayou line, having a continuous fall, as shown on high-water chart.

If the water had remained between the levees below Helena, the difference of elevation between the ground at Costello's Gin and the flood level at the dikes at Jefferson Lake, instead of being about 6 feet would have been nearer 9, and with a great coincident flood from the Arkansas River, much more.

From March 28 until April 3 the water at Helena rose 1¼ feet, and at the latter date was rising at the rate of three-tenths foot per day. Judging from the long period of practically standing water at Memphis this rise would probably have continued, but for breaks in the neighborhood, for a long time, and been repeated (with the levees intact) at Arkansas City.

If the Red Fork system was extended to near the mouth of Cypress Creek, and the same high-water elevations existed, the difference of elevation at Costello's Gin and water surface at the mouth of Cypress Creek would be about 1 foot (the latter 161 Memphis datum). But with the levees intact and the same discharge as the present flood, augmented by a great flood from the Arkansas River, it would be more like 5 feet. Therefore the water would continue to flow over the country between lapping levee lines, overflowing the lands behind the main levee as heretofore, but to a much less extent.

Owing to the continued rise of the crest of the great floods with the construction of levees on the heretofore unprotected fronts, the only practicable solution of the problem for complete protection to this back country seems to be the closing of Cypress Creek by a line from Lake Jefferson to Boggy Bayou Crossing, opening the latter and turning the discharge of Cypress Creek and its tributaries into it. This is dependent on much larger channels than at present exist to carry off the natural drainage, and its practicability can not be demonstrated until a survey is made and the general drainage features of the back country developed.

The discharge between the levees was about 120,000 cubic feet per second. The country affected by this discharge is shown on accompanying map of overflowed area. The duration of the overflow was comparatively short, causing little damage or detriment to planting interests. The water at first flowed from Cypress Creek through a cross drain, Newmans Slough, nearly 3 miles west of Costello's Gin. This ditch can be closed at a small expense, thus keeping out lesser floods and shutting off a considerable portion of greater ones.

Discrepancies in the gages on the Red Fork line from Lincoln County line to Lake Jefferson (which were set prior to my taking charge of that district) make it impossible to submit high-water profiles of this reach with the present report. The following extract from the report of Mr. G. E. Buck throws some light on the conditions on the Arkansas River line:

"As near as our imperfect previous watermarks showed, the river was 2 feet higher at Red Fork, 18 inches lower at Medford Storehouse, 3½ feet lower at Pendleton's, and 4 feet lower at the upper end of district than the highest water known, showing the direct influence of the Mississippi River to the upper end of the district. * * * The back water from the Mississippi River, coming in between the lower end of the present line of levee at Jefferson Lake and the mouth of Cypress Creek, covered full two-thirds of the whole area of our district, and fully one-half of this was covered from the water being held up on us by the cross line of levee known as the Boggy and Amos Bayou levee.

"When the water commenced falling in the Arkansas River, it fell 16 inches at Pendleton before commencing to fall at all at the Medford stone, and while still rising slightly at Red Fork. This was caused by the inflow from the Modoc Break and White River through Cypress Bayou, which connects the White and Arkansas rivers, emptying into the Arkansas just below the Arkansas Post, opposite this point."

LEVEE SECTION.

The high water in this subdistrict has demonstrated very clearly the value of a good sod which holds the slope in place preventing sloughing even when the levee is saturated; also, of the deep muck ditches at certain points of weak foundation and the good results obtained by shallow seepage ditches; also the fact that 1 on 3 slopes when well sodded will withstand wave-wash.

In ordinarily good soils the standard section will remain intact with back slope dry to near the base behind, with water nearly to the top in front, if constructed strictly in accordance with the specifications of 1896 (on good foundations), with scrapers in 2-foot layers, without banquette up to 14 feet in height, increasing in strength in some instances with the duration of the flood.

All the new work in the subdistrict built by the Government has remained throughout the high water almost without showing a flaw, some standing with the crown of the levee but a few inches above the water, while that put up in large layers or with wheelbarrows shrunk and cracked under the compacting influence of the water to a dangerous degree. Some of the latter was built in 1893 and 1894, and some as late as last winter by the Tensas Basin Levee board.

Banquettes should be constructed at all points where the foundation or material of which the levee is built is weak, and behind all levees over 12 feet in height, irrespective of foundation or material, in order to have working room and material in time of very high water. In this district banquettes of standard section, 20-foot crown, with 1 on 10 crown slope and 1 on 4 back slope, have proved effective and satisfactory for levees up to 20 feet in height. For excessive heights and bad foundations they should be increased in width and slope to a degree commensurate with the conditions.

In a report submitted in 1895, accompanied by charts comparing the standard third-district section with foreign sections and those used in this country since 1717, I advocated the investigation of the line of saturation in levees of different materials by boring holes in the back of the slope during high water, but when preparing for the experiments the danger of causing a break occurred to me so forcibly that they were abandoned. The dry condition of the land slope of many of our levees, and saturation to the top of many others, would indicate that no regularity exists in its position with the levees constructed in the present manner.

The great desideratum is a levee homogeneous, inherently strong, constructed in close and compact layers, not loosely thrown together and subject to excessive shrinkage. The high-water pressure is an active agent in compressing and thus strengthening the levees.

The use of the banquette as a roadway is not advisable in this district, unless, as in Europe, a well-prepared supersurface of stone or hard material is used.

Much trouble from cattle at high water and hogs at low would be avoided by fencing the line above Gaines Landing.

It is a difficult matter during the strain of a very high water to impress on those in charge of details the necessity of economy in the expenditure of materials. In many places where earth alone would suffice, sacks and lumber were used in large quantities; where bagging was used as a protective from wave-wash on a sodded slope it acted satisfactorily, also in connection with bulkhead work in place of sacks, but it was almost impossible to have it used. Sacks seemed the panacea for all high-water ills—wave-wash, topping, sloughs; and even roadways. Many more are expended than is necessary. On the Red Fork line the water was held above the natural crown of the levee for miles without the use of sacks.

Legislation.—A law should be enacted by the legislature of the State of Arkansas prohibiting the running at large of stock during the high water. Much expense and trouble is incurred through the necessity of keeping it off. It becomes necessary to adopt very arbitrary methods, and thus incur the ill will of the community, in order to avert serious consequences from the cattle evil. If the levees are to be maintained during a flood, cattle must be kept away from them.

* * * * * * *

Very respectfully,

H. ST. L. COPPÉE, *Assistant Engineer.*

First Lieut. H. C. NEWCOMER,
Corps of Engineers, U. S. A.

REPORT OF MR. E. C. TOLLINGER, ASSISTANT ENGINEER.

GREENVILLE, MISS., *May 15, 1897.*

SIR: I have the honor to submit the following report on the surveys, construction, and repairs of levees in the Upper Tensas district in Arkansas and the Lower Yazoo district in Mississippi, below Greenville, from May 1, 1896, to May 1, 1897. The respective lengths of these subdistricts is, in Arkansas, 40 miles; in Mississippi, 95 miles.

Shore line.—The bank has caved at Upper Leland (470 R), Mathews Bend (507-509½ R), 2½ miles; Warfield (483-485 L), 2 miles; Longwood (500-504 L), 4 miles; below Leota (513-515 L), 2 miles; Homochitta (535-538 L), 3 miles; Shipland (543-546 L), 3 miles; Hays (552-555 L), 3 miles; Arcadia (558-560 L), 2 miles; Duvals-Brunswick (567-574 L), 7 miles.

The caving has been sufficient at Upper Leland to warrant recommending a new line, which is shown on the blue prints forwarded you. Estimates have been made for new loops on the Mississippi side at Deerfield crevasse, Leota, Shipland loop, Promised Land (Shipland) crevasse, Hays loop, and Brunswick. These may not all be absolutely necessary, which fact can not be known until the river recedes within banks. The new loops are needed at Deerfield crevasse, Promised Land (Shipland) crevasse, and Ingomar to Chotard.

Construction.—When I submitted my last annual report, all of the contracts had been completed, thus bringing the controlling levee up to 3 feet above highest water and to a standard section 8-feet crown, slope 1 on 3, including banquette to levee, where above 12 feet in height. These dimensions are increased at Whisky Chute Levee and Grand Lake Levee. Contracts were let November 23, 1896, to be paid from allotments of 1896-97. These contracts required the levee to be brought up to 4½ feet grade above highest water; enlargement to be placed on the river side, with the exception of Whisky Chute, where the enlargement is on the land side. Whisky Chute and Grand Lake levees have a grade 6 feet above highest water, slopes 1 on 4, crown 10 feet; no banquette at Whisky Chute.

Muck ditch.—The muck ditch affords the best means known to examine foundations, and the prejudices of contractors and inexperienced persons should not be seriously entertained.

False berm.—The slope of the enlargement extended in several places near to, and in others into, the old borrow pits. Where the old borrow pits are deep and can not be drained it is best to construct a false berm to prevent water lying against the levee. None been required during this fiscal year.

Banquettes.—Near the Louisiana line a banquette has been approved. This is along a section of old levee with deep borrow pits close to old slope on land side. Banquettes lying on the land side should be built with the levee, and not considered as a future enlargement. All later enlargements, of whatever nature, should be made on the river side to avoid land-side borrow pits, to cover weak spots in the old levee or its berm, and to prevent any sloughing of the new part from the old. The use of the banquettes for highways and the construction of banquettes by local authorities are subjects for consideration when determining whether to include them in the original levee.

Settlement of levees.—The light and heavy strata of soils in this subdivision are favorable for the settlement of the foundation of ordinary levees at any season and under any conditions. This settlement in most instances is from two-tenths to five-tenths, and is due chiefly to spongy condition of surface vegetable matter, which should be removed, but rarely is. Greater sinking has taken place in foundations where tested for depths of 10 to 12 feet and found to be favorable for levee construction, the sinking amounting to several feet during construction, and continuing to sink for three years afterwards. These were in old beds of lakes.

Shrinkage.—The gross grade to which these levees have been built added 8 per cent to the area per scraper work in 2-foot layers and 8 per cent to barrow work in 6-inch layers thoroughly tamped during construction. The contractors regard this last clause as prohibiting barrow work.

* * * * * * *

High-water marks.—The high waters of 1890, 1891, 1892, 1893, and 1897 are marked by spikes driven in trees. These spikes are stamped to give respective high waters, and where practicable are driven in the same trees. The spikes are connected with the stone line benches. There are no high-water marks along the line of the levee for the years between 1893 and 1897, as the river was not more than bank full at any time between these dates.

High-water gages.—High-water gages made of inch cypress, 4 inches wide, 6 feet long, marked in tenths, with zero at the middle, were nailed on trees containing high-water spikes of 1892-93, the zero marking the highest water.

These were read during the flood of 1897. Tabulation of these compared with floods of 1892-93 accompanies this report. On the Mississippi side the gages were set from elevations furnished by the chief engineer of the Mississippi levee board.

Datum plane.—The datum plane used in all this work was, as instructed, Memphis datum.

Drainage.—This important subject should receive a thorough study, and experiments made on a large scale to determine the best manner of procedure. A great many of the sloughs that are the primary cause of most of the crevasses, and form a large part of the expense of high-water protection, are due to water lying against the land side of the levee.

REPAIRS.

Weed cutting.—The weeds were cut during the month of June, July, August, and September, no other repairs being undertaken. With the exception of a few patches, the line is well protected with Bermuda sod. Some sodding was needed but the season was too dry to undertake it. No repair work was done by the Mississippi levee board or the United States below Greenville on the Mississippi side. The line constructed by the United States did not need any. The levee board does not approve of such work as keeping the levee free from weeds, vines, and trees, and thoroughly sodded. This is due mainly to the constant changing of grades and caving off of levees. They do, however, carefully sod their new levee, but fail to give proper care afterwards to insure permanent growth. A report showing the condition of the Mississippi levees in my subdistrict during the high water of 1897, by Mr. Kerr, who made observations, has been submitted.

Urgently needed repairs, Upper Tensas district.

To replace wave wash will require the placing of 10,000 cubic yards of earth, at 20 cents	$2,000
Muck ditches in old levees:	
Lakeport, stations 981-995, 1,400 cubic yards, at 20 cents	280
Sterling, stations 1868-2000, 3,700 cubic yards, at 20 cents	740
Weed cutting, Stations 0-2009, for this season	1,000
Contingencies	1,000
	5,020

If the contracts in force are brought up to 3 feet above 1897 water this will provide for replacing wave wash, except at Lower Leland, where the work will cost about $300.

SURVEYS.

Surveys of the levee line were made to determine the yardage required to bring the levees up to 5 feet above the highest water, including banquettes. A pipe line of iron benches were put in position along the land side crown on the Mississippi side of the river; this work had been done on the Arkansas side. These are frequently referred to during construction, surveys, and flood period. Many of these benches were destroyed (elevations) during the flood of 1897. The contracts let on November 23 were cross sectioned before the contractors were on the ground. This was found to be advantageous, as it enabled inspectors and rodmen to devote more time to active construction.

Condition of levees before high water of 1897.—Surveys were made to determine the condition of controlling line. On the Arkansas side the line was found to be up to constructive grade, which was 3 feet above the highest water, except where barrow forces were used, which, however, was only a small per cent of the line. The levee was either new or had been enlarged since any high water. On the Mississippi side the levee was found to be up to 3 feet grade, with few exceptions. The sections were under contract and completed before the flood except part of one contract. Many of these levees were old, with defective foundations and trunks.

HIGH-WATER PROTECTION, 1897.—UPPER TENSAS DISTRICT, STATIONS 0 TO 2109.

Organization.—For high-water purposes the district was divided into four sections, as follows: Stations 0 to 462; 462 to 720; 720 to 1250; 1250 to 2109.

Distribution of supplies.—Barges were loaded with lumber and located at convenient points along the line, sacks, wire, nails, and tools being loaded also. At other points along the line sacks and other materials were stored for emergency purposes, and quarter boats were fitted out with materials and tools for 300 laborers, being the most effective method of concentrating a large force on any dangerous place. The actual work of high-water protection is shown in the accompanying table of high-water operations.

* * * * * * *

Use of steamboats.—The barges and quarter boats containing supplies and materials were transferred to points along the line by one of the United States steamers, and were returned to headquarters at Greenville, Miss., when no longer required. The work done consisted of the following:

Four trips to Upper Leland, Ark., from Greenville; three trips to Lower Leland, Ark., from Greenville; two trips to Vancluse, Ark., from Greenville; one trip to Lakeport, Ark., from Greenville. These trips averaged about four hours each, except the one to Lakeport, which required about half a day.

* * * * * * *

It is impossible to give the amount of dirt placed in the topping by the day forces, but it is necessarily small in proportion to the cost, as such work always is when done under the many disadvantages to be overcome in high-water work. The work of topping was begun March 21 and completed March 31, except from Stations 0-388. No topping was done south of Station 388 after March 30, as the river had come to a stand owing to the crevasse at Deerfield (491 L) March 28. During April the work was generally along the base of the levee to prevent sloughs. A small force of wheelbarrows was used topping the levee on the north side of Leland Neck and on river side to cut off seepage. This method proved very satisfactory. Much attention was paid to draining the land side slope, and the results have been satisfactory.

The work on high-water protection in the Lower Yazoo district on the part of the United States consisted in paying for a part of the materials and labor used, and the furnishing of barges, quarter boats, skiffs, to the Mississippi levee board. The other work done during the flood was observations on high-water slopes by Mr. L. Y. Kerr, and a reconnaissance to determine the flood limits, by Mr. W. R. Harvey.

REMARKS ON THE FLOOD OF 1897.

In many respects the high water of 1897 was one of the greatest on record. The repeated rises in the Ohio, Cumberland, and Tennessee, and their long duration made certain that we would have, without any aid from the Arkansas and White rivers, a great flood in the Mississippi in March and April. This opinion has been fully verified. Had the Signal Service warnings, which were given daily and in ample time, been heeded, the people living in the flooded areas would have saved much of their property, either by building mounds to put their stock on or by driving it to the hills. The gage at Greenville, Miss., March 12, read 35.7 feet; March 28, 46.6, a rise of 11 feet in the sixteen days, being about seven-tenths per day, 46.7 being the maximum height recorded (on March 29). The rise was so pronounced that active operations had to be kept up day and night, employing every available man, boy, and team till relief came. The conditions during March 26, 27, and 28 were full of grave apprehensions. The water was in many places at the top of the levee and in others running over, and rising four-tenths each twenty-four hours. It was plainly to be seen that the levees could not hold out much longer. Where they would give way first was not known until the Deerfield crevasse was reported on the night of March 28. This crevasse was followed by one at Sledge place March 29, then by Stops and Stokes March 30. These crevasses brought the river to a stand on the 29th, followed by a decline at once, which has continued except in the lower end of the district, which has been fully reported on by Mr. Kerr. The gage reading at Greenville, on the 13th of May, 40 feet at close of day. It was fully expected that the levees in Arkansas (with the exception of a few old levees) would be held at a little expense and would successfully resist the floods to nearly the construction grade of 3 feet above the high waters of 1892 and 1893. This opinion has been fully sustained. The greatest fear entertained was from sinking levees and levees that spread when saturated. These levees were kept well above to guard against this trouble. The levees constructed after the flood of 1893 and before the flood of 1897 (1894, 1895, and 1896 being low-water years) up to this season had no water against them. Most of the line in Arkansas was newly built or enlarged between these dates. These were dry years, and it was thought that there would be a pronounced shrinkage when the water had stood against the levees for several days. This fact was brought out by the levees sinking from two-tenths to 1 foot. At this stage of the flood the levee trunk had the appearance at many places of being quite moist; but this seemed to disappear soon after the shrinkage took place and the river became stationary.

The lesson taught by the flood of 1897, as well as past floods, is that the trouble is at or beneath the foundations of the levees in most cases. This is especially true in regard to old levees, which will give trouble and expense during every flood of long duration.

Treatment of old levees.—The most economical method of treating old levees, and one that has much merit in it, is the cutting of a large muck ditch along the river slope and filling it with good earth, well tamped during construction, and the strengthening of the back part of the levee by a banquette extending well up the slope. This banquette should be 6 feet below the crown of the levee, with crown 30 feet; 3 feet drop and rear slope of 1 on 5.

Standard sections.—The levees built to the present standard section seem to be well adapted to the purpose for which they were constructed. Cases arising during construction, such as deposits of silt or defective foundations, which require special treatment, sometimes occur. The levees built of sand are of little expense to keep up and give no trouble. Those constructed of silty material and buckshot and sand mixed were unreliable, requiring constant care and expense during the high water.

Suggestions for new construction.—It has occurred to me that in the event funds are not available to prosecute the construction work as now seems necessary, that the levees can be made to resist a flood not exceeding 47 feet on the Greenville gage, if the lines are topped and strengthened with a large banquette in rear, and muck ditch along river side of slope. An estimate for this can be readily taken from the data accompanying this report.

Specifications.—The levees built in accordance with the specifications of 1896, have given no trouble. Their trunks have been dry nearly to the bottom, as demonstrated by sinking holes with a post-hole digger from the river-side slope to the land-side slope while the river was above the 44-foot stage on Greenville gage. These experiments were made on levees with and without banquettes. The borings plainly marked the presence of materials not suitable for levee building. Levees built of buckshot, good loam, and sand mixed, proved satisfactory; that built of strata of good, bad, and indifferent materials was found to be pretty well saturated. The changes recommended in the specifications are the use of a large roller for foot layers in certain tough buckshot and clay soil. The banquette for old levees should have a crown of 30 feet, drop of 3 feet, and rear slope of 1 on 5. Those built in conjunction with new levees have a sufficient section.

All silt-containing levees should have 1 on 10 slopes on the land side. Previous to this flood the levees in Arkansas have not been of a section sufficient to warrant any experiments. It is a difficult matter to perfect the organization during the high-water periods so well as to entirely prevent the wasting of more or less material during this trying time. Sacks are often used in places where lumber and earth would answer at less expense. For wave wash and sloughs, however, nothing takes the place of sacks; even in these, waste is noticeable.

* * * * * * *

Very respectfully,

E. C. Tollinger, *Assistant Engineer.*

First Lieut. H. C. Newcomer,
Corps of Engineers, U. S. A.

REPORT OF MR. J. D. VAN METER, ASSISTANT ENGINEER.

Greenville, Miss., *May 15, 1897.*

Sir: I have the honor to submit a report of levee improvement in the Lower Yazoo district, north of Greenville, Miss., from May 1, 1896, to May 1, 1897.

This subdistrict covers the entire Bolivar County front and the upper half of Washington County, 87 miles of levee line.

At the beginning of last season a grade of 5 feet above the highest water was adopted by the United States for raising levees north of Greenville. The State board, however, considered it a more judicious expenditure of their funds to work to a 4-foot grade, and in accordance therewith the enlargement of certain lengths of levee known to be relatively low was undertaken by the board and completed before high water of this season, with also a new levee just north of Greenville, their addition to the levee yardage being 1,218,000 cubic yards for the past year, contained in 862 stations of enlargement and 178 stations of new levee, distributed over the following lengths of line:

Lake Beulah to Buckridge, Stations 2066 to 2590.
Across Catfish Point, Stations 2880 to 2959.
Millers Bend, Stations 3909 to 4168.
New loop above Greenville, Stations 4340 to 4463.

The work undertaken by the Government in the interest of levee improvement has been as follows:

At the time of last report upper and lower sections of Buckridge levee were unfinished, there remaining 12,745 cubic yards to complete the upper section and 16,001 cubic yards on lower section. Both were completed before the expiration of the time extended for the completion of these contracts, May 30, 1896.

Weed cutting was begun about June 1, and continued until August 1, when the line had been cleared of weeds from Stations 0 to 3640 (Mound Landing), about 70 miles.

Chaining and reenumeration of the line was begun July 15, the object of this survey being to establish a consecutive enumeration of stations which had been broken by new loops built from year to year. As a permanent reference, iron stakes were erected every 10 stations, beginning at zero. This stake consists of a piece of piping 4 feet long, with a 6-inch flange at the bottom and a cap screwed on the top. These markers, or bench marks, so called, are sunk 3 feet in the levee on the land-side slope, and just below the level of the levee crown. They have since been connected with the United States precise bench marks, and serve not only to indicate the station, but as bench marks.

In accordance with the plan of raising levees to 5 feet above the high water, a survey of this line was begun about August 15 to determine the length of line that might be contracted for enlargement out of the current allotment for the Lower Yazoo district. On estimates furnished, contracts were awarded for levee enlargement from Stations 0 to 2066, in contracts divided per 100 stations, except two sections, Stations 1000 to 1200, on which bids were rejected. The letting of contracts was on November 23, 1896, for completion before October 1, 1897. 1,309,901 cubic yards are comprised in the 19 contracts, as shown by the computed cross sections for enlargement. Five contracts were begun in December and others at later dates, until work had been begun on all except four contracts at the time of suspension by high water. These four contracts are indicated in the tabulated statement accompanying report, showing extent of contracts and progress to May 1, 1897.

LEVEE PROTECTION, HIGH WATER, 1897.

By March 15 all work on contracts was suspended, and it was then apparent the levee system would have to undergo a very severe test. The Government force of inspectors and rodmen then employed on construction were assigned to duty on levee protection from Stations 0 to 3336 (Mound Landing), the levee board taking charge from Mound Landing to Greenville. It soon developed that there was a good deal of levee along this line of insufficient height, and a temporary topping had to be resorted to. The method employed was by plank backed up with earth, or simply with sacks of earth in localities greatly exposed to wave wash. However, in a few places topping was done with teams and scrapers where material could be hauled over the land-side slope without detriment to the levee. Twenty-four and one-half miles were topped by the United States and levee board forces in the subdistrict north of Greenville at time of breaks.

The first break that occurred north of Greenville was on March 29, at Station 605 (Sledge plantation). This levee is about 10 feet high and the break has attained a width of 1,200 feet. Two breaks occurred on March 30—at the Stokes place, Station 1005, and at Stops Landing, Station 3200. At both places the water was to the top of the levee and seeping very badly, though no indication of especial weakness was manifest except in the Stops Landing Levee, when a few hours before the break a very bad slough occurred and general sinking of embankment for 200 feet on either side. The levee at this point was about 16½ feet high and of very poor material, and after sloughing began was soon beyond control. The Stokes break was in a 13-foot levee, and the only indication of unsound condition was a sand boil that presented no alarming features. Both of these breaks occurred at night, when men and materials were hard to obtain. The Stokes break was widened to 2,900 feet, and Stops Landing break to 2,000 feet, with water running through at a moderate depth and no widening of crevasses.

The land generally between the Yazoo and Mississippi rivers has been overflowed from the six breaks on the east bank of the river (one in the Upper Yazoo district and five in the Lower), only the highest ground being exempt from overflow.

Very respectfully,

J. D. Van Meter, *Assistant Engineer.*

First Lieut. H. C. Newcomer,
Corps of Engineers, U. S. A.

REPORT OF MR. LUTHER Y. KERR, INSPECTOR.

GREENVILLE, MISS., *May 3, 1897.*

SIR: I respectfully submit the following report of my work and observations during the latter half of March and month of April, 1897, on the Lower Yazoo levees below Greenville:

GENERAL CONDITION OF THE LEVEE.

The line of levee from Greenville to Brunswick was supposed to be up to a 3-foot grade. But this was not the case. It would probably average 2½ feet. The entire line will average about 12.5 feet in height, about 25 per cent of which has a banquette with 20-foot crown and 1 on 4 back slope. The crown of banquette begins about 8 feet below grade and has a crown slope of 1 and 2 on 20.

All the levees built by the levee board in recent years have been built with 8-foot crown, and 1 on 3 slopes on both sides. But beyond this piling up of earth to a certain cross section, very little else is done for the levee until the time comes to resist a flood. No slashing of timber is done beyond the base of levee even on the most recent construction. Trees are allowed to grow right along the base of the levee. Weeds, briers, cottonwood, sycamore, or any other objectionable growth, is allowed to grow from year to year on the levee, smothering out the Bermuda, shading and filling the levee with roots.

There is in this line of levee considerable old levee that was built probably fifty years ago, at a time when logs and stumps were not considered objectionable and grubbing would have been considered an absurd waste. These old levees have always given more or less trouble during floods by seepage, sand boils, and sloughs. Several very dangerous sloughs, in fact the only very dangerous ones, and the two crevasses, occurred in just such old levee. As a rule they have very steep back slopes. This is partially due to the continued use of the levee for public travel, which widens the crown, lowers the grade, and reduces the slope. No attempt is made to keep hogs or travel off the levees except in times of danger, although a prohibitory law exists. The entire line of levee where it is worthy of confidence on its present location should be cleared of brush and briers, and the timber slashed on both sides for a distance of 100 feet from base of levee. All the old levee should be thoroughly muck ditched and grubbed before any enlargement is put on, and a large part of it should be shifted to a new base entirely.

CREVASSES.

The crevasse that occurred at Deerfield Plantation, 3 miles above Wayside, Miss., at 8.30 p. m., March 28, was in one of the old-time levees, about 11 feet high, with a very steep back slope. It was reported that the levee was broken by the waves rolling over the levee, but it is very probable that it broke from a sloughing off of the steep back slope. The crevasse in the Promised Land levee was the result of sloughs caused by stock on an old rotten levee. This levee was about 8 feet high, with water at top of levee on river side and about 5½ or 6 feet below top on land side. The point where the crevasse occurred, about Station 3570, is in a manner protected by an old levee projecting out to river bank just above, and very materially reducing the inpour. It is very probable that this crevasse would not have widened very much, had it not been for the rotten condition of the levee and trees and stumps that stood near, causing eddies that cut away considerable from the river side.

STOCK.

As the plantations and back country became inundated, the stock was moved out on the levee until hundreds of head of horses, mules, cattle, and hogs were lotted and fed on the levee, doing considerable damage in the way of denuding the levee of Bermuda grass and causing numerous sloughs.

PIPE BENCHES.

The pipe benches that were set last fall along this line of levee will be of very little service after the high-water fight is over, until they are reset. These benches were set on left crown of levee and allowed to stand from 1 to 2 feet above the surface, thus making them very much exposed, and a great many of them have been disturbed.

GAGES.

Ninety-two high-water gages have been set, one about every mile. These gages were 5 feet long and set by Memphis datum to read 3 feet above the high-water elevations as furnished by Mississippi Levee Board. Eleven of these gages could not be set to elevation, as there were no benches below Station 4663, but they were set approximately close by the water surface.

High-water spikes.—Spikes one-half inch by 7 inches, marked "H. W. '97," were driven at each gage at the high-water line reached before any crevasse occurred.

When the levee broke at Deerfield on March 28, the river began to recede at Greenville at once and by April 10 had fallen 2.2 feet. This fall had decreased as it went down the river until, at Brunswick, there was only about 0.1 foot fall.

Back water.—This natural flood height was exceeded some in the lower part of the district, caused by the engorgement of the river at Vicksburg by the return water through the Yazoo River. This backing up or change of slope was felt as far up as Longwood, Miss., being about 1.1 feet at that point and increasing to 1.8 feet at Brunswick, Miss., where it was rising at the rate of 0.2 foot in twenty-four hours when the crevasse occurred in the Biggs Levee, 5 miles below Delta, La., at 10 o'clock p. m., April 16.

Holding front levee.—At all points where there were 2 lines of levee existing, the front line has been held by the Mississippi levee board. The most important case of this kind is between Chotard and Brunswick, where the front line is backed up by 200 stations of fine levee built by the United States in 1894–95. The front levee not having caved off, it was decided to make the fight on it. It is questionable in my mind whether one is justified in incurring the additional expense of saving an old front levee, especially where there is immediate danger of caving, and the levee can not be expected to last more than one season at best, when there is a good standard well-sodded levee just behind.

Levels were run over the United States loop from Chotard to Brunswick, and it was found to be in good shape and up to grade, with the exception of about 4,000 feet, which have settled nearly 1 foot. There was no water on river side of levee except seep water. The overflow water on land side was within 3 to 4 feet of top of levee. The caving at this point had gotten within 30 feet of the old levee at the angle at Chotard Landing. At the request of Mr. B. B. Gordon, assistant engineer, Mississippi levee board, I staked off a small loop in the angle of the old levee. This loop would contain about 3,000 cubic yards, and cost probably $500, which he intended to build if the caving got any closer to the levee.

Eagle Lake Levee.—The levee known as the Eagle Lake Levee begins at about Station 5200, the former terminus of the Lower Yazoo Levee district system, and runs along the north side of Eagle Lake in an easterly and northerly direction a distance of about 5¼ miles, making a new terminus to the system. This levee was built by the Mississippi levee board in 1886, with some kind of understanding with the planters that they (the planters) would keep the levee up. But nothing has been done to the levee since its construction.

It is about 1 foot below the present grade of the levee at the old terminus, and has a drop of about 4 feet in the 5¼ miles. There was a small crevasse in this levee at the upper end, but it was not considered of enough importance to mention with the other crevasses, as it was only about 50 feet wide, and the water was running over the entire levee from there down. The difference in elevation of the water on land side and that on river side of levee was so small that no further damage was done. There was probably 1½ feet fall over the levee at the upper end, but this rapidly decreased and had entirely disappeared at a point 1½ miles below, where the water was on the same level, and from 1 to 2 feet above the top of the levee.

* * * * * * *

Very respectfully,

LUTHER Y. KERR, *Inspector.*

Mr. E. C. TOLLINGER,
United States Assistant Engineer.

Operations for high-water protection of levees, third district, improving Mississippi River.

LOWER YAZOO LEVEE DISTRICT.

Stations.	Below Cairo.		Materials used.		Remarks.
	Miles.	Bank.	Sacks.	Lumber.	
			Number.	*Feet.*	
0- 25	365	L.	....	....	Raised and enlarged to 5 foot grade previous to high water.
25- 170	366	L.	25,000	35,000	Topped with plank backed by earth; 4 sloughs treated.
170- 188	369	L.	....	....	Raised and enlarged previous to high water.
188- 207	369	L.	20,000	25,000	Topped with plank backed by earth; 8 sloughs treated.
207- 253	369	L.	....	....	Raised and enlarged previous to high water.

Operations for high-water protection of levees, third district, etc.—Continue

LOWER YAZOO LEVEE DISTRICT—Continued.

Stations.	Below Cairo.		Materials used.		Remarks.
	Miles.	Bank.	Sacks.	Lumber.	
			Number.	*Feet.*	
253- 270	370	L.	2,000	5,000	Topped with plank backed by earth 500 feet, which were raised 2 feet wi and scrapers.
270- 290	370	L.	6,000		Topped with sacks; badly exposed wash.
295- 300	371	L.	6,000		Numerous sand boils, causing sink slope; used brush and sacks.
353- 358	372	L.			Topped with scrapers and sacked wave wash.
385- 440	372	L.	12,000	10,000	Topped with sacks; lumber used fo water.
440- 458	373	L.			Topped with scrapers.
458- 476	373	L.	5,000		Topped with sacks.
533- 557	375	L.			Temporary topping with scrapers.
605	376	L.			Break occurred Mar. 29; widened feet. No work here except to slas around in front, which has caused n ciable decrease in the flow.
612- 975	376	L.			Levee well above water; no work do
975-1058	380	L.	28,000	20,000	Topped with plank, reenforced by bad slough at 976.
1005	380	L.			Break occurred Mar. 30; widened to 2, Some work here by Levee Board to flow by a system of brush and sac very little accomplished.
1200-1235	393	L.	1,000		Topped with scrapers; old levee at 123 with sacks to deflect current from main levee.
1235-1500	394	L.			In good condition. No work.
1500-1600	399	L.	25,000	10,000	Topped with scrapers, sacked in fron ping; 900 feet of this line raised larged before high water. 3 sloughs above Station 1525. Spur dike at 1580 raised.
1860-1973	400	L.	25,000		Topped with sacks, and in places against wave wash.
1980-2050	404	L.	10,000	15,000	Topped with lumber and sacks.
2066-2590	404	L.	2,500		Very little work; was recently rai enlarged by levee board, and stoo flood; a brush mat sunk at angle, 2100 and revetted with sacks to scour from current; 3 sloughs betw tions 2150 and 2200 treated.
2590-2650	417	L.	12,000	12,000	Topped with plank backed with sack fight here made along old Buckridg the water not reaching the main lin
2650-2870	418	L.	20,000		Topped with sacks.
2870-2959	421	L.	5,000		(Catfish Point.) 3 spur dikes sacked.
2959-3180	431	L.			Levee in good condition. No work.
3200	434	L.	5,000		Break March 30, caused from slough a ing; widened to 2,000 feet; leve attempted to hold ends and decrease brush dikes; first dikes lost; the lat have been made to hold.
3300-3336	435	L.	5,000		Topped with sacks.
3336-3469	436	L.	20,000		Do.
4171-4339	460	L.	19,000	30,000	Topped with plank backed by earth raised with sacks; some topping al sacks.
4370-4444	476	L.	15,000		Topped with sacks.
4444-4570	477	L.	30,000	30,000	(Main street at Greenville.) Toppe plank and sacks.
4570- 0	478	L.	7,000		In Greenville.
0- 30	479	L.	1,000		
30- 225	480	L.	21,000	37,000	
290- 530	484	L.	3,000	5,000	
530- 570	490	L.	6,000	5,000	
570- 580	491	L.	1,000		
780- 870	492	L.	10,000	25,000	
870-1000	493	L.	7,000	35,000	
1000-1230	494	L.	7,000	40,000	
1280-1320	499	L.	2,000		
1350-1545	500	L.	12,000	60,000	Longwood Levee.
1545-1770	502	L.	4,000	37,000	
1810-1890	510	L.		16,000	

Operations for high-water protection of levees, third district, etc.—Continued.

LOWER YAZOO LEVEE DISTRICT—Continued.

Stations.	Below Cairo.		Materials used.		Remarks.
	Miles.	Bank.	Sacks.	Lumber.	
			Number.	*Feet.*	
1930-2030	512	L.	12,000	24,000	Leota Levee.
2030-2070	513	L.	10,000	....	
2070-2200	514	L.	....	27,000	
2295-2340	517	L.	6,000	15,000	
2470-2590	527	L.	21,000	....	
2690-2750	529	L.	14,000	37,000	
2775-2850	531	L.	....	18,000	
2860-2925	532	L.	5,000	9,000	Above Mayersville.
2925-2980	533	L.	5,000	12,000	Below Mayersville.
2980-3050	534	L.	8,000	12,000	Clover Hill Levee.
3050-3150	535	L.	19,000	2,000	
3150-3275	536	L.	500	12,000	
3290-3375	539	L.	1,000	16,000	
3400-3435	540	L.	4,000	....	Ben Lomond.
3435-3570	541	L.	44,000	40,000	Shipland Levee.
3570-3640	545	L.	....	14,000	
3725-3740	551	L.	600	4,000	
3790-3940	552	L.	500	20,000	
3980-4100	553	L.	38,000	....	Halls and Hays Landing Levee.
4115-4180	554	L.	12,000	....	Government Hays Levee.
4290-4320	557	L.	9,000	....	
4320-4365	558	L.	3,000	9,000	
4365-4470	560	L.	22,000	24,000	Arcadia.
4600-4614	566	L.	1,000	....	
4648-4715	567	L.	2,000	15,000	Duvalls, Ingomar, and Chotard.
4715-4900	568	L.	52,000	....	
4900-5040	570	L.	5,000	32,000	
Total	......	......	670,100	789,000	

UPPER TENSAS LEVEE DISTRICT.

Stations.	Miles.	Bank.	Sacks.	Lumber.	Remarks.
Red Fork line:					
1-200	......	......	....	....	No work; levee 2 feet above water (Red Fork).
200-210	......	......	....	....	Topped in few places with 6 to 8 inches earth.
210-250	......	......	....	....	No work; levee about 8 inches above water.
250-380	......	......	....	....	Topped from 12 to 14 inches. 1 slough repaired.
380-460	......	......	....	....	No work; 16 inches above water.
460-470	......	......	....	....	No work; 2 inches above water.
470-500	......	......	1,000	....	Topped with loose earth fixed with brush and sacks.
500-575	......	......	....	....	Topped low places with loose earth.
575-655	......	......	....	....	No work; levee 2 to 3 inches above water.
655	......	......	2,900	....	Two dikes built of brush, piling, and sacks at end of levee.
Amos Bayou line:					
145-270	......	......	....	....	Topped with teams; revetment at Station 270 to protect end.
138-145	......	......	3,800	....	A crevasse; dikes of piling, brush, and sacks built at ends.
0-138	......	......	1,490	....	Topped and strengthened with teams; sacks used in sloughs.
Main line:					
0- 66	......	......	45	....	Sacks placed in washes; levee above high water.
66- 79	......	......	10	....	Sacks placed in washes.
79- 180	......	......	166	....	Sacks placed in washes and sand boils; levee was 3 to 3½ feet above high water.
180- 220	......	......	2,800	500	Sack revetment of back slope Stations 181 and 216-217; sand boils hooped with sacks (50 yards bagging).
220- 360	......	......	....	....	No work.
360- 420	425	R.	1,000	1,050	Topped with teams (360 to 370); afterward braced this with lumber; topped with sacks and lumber from 370.
420- 484	426	R.	1,800	....	Sacks placed in wave washes.
484- 520	427	R.	....	....	No work; enlarged recently 4½ feet above water.
520- 604	428	R.	3,000	2,250	Topped by teams with lumber and sacks.
604- 750	429	R.	2,800	1,500	Low places topped with sacks; sloughs repaired.

Operations for high-water protection of levees, third district, etc.—Continue

UPPER TENSAS LEVEE DISTRICT—Continued.

Stations.	Below Cairo.		Materials used.		Remarks.
	Miles.	Bank.	Sacks.	Lumber.	
Main line—Cont'd.			*Number.*	*Feet.*	
750	432	R.	1,200		Spur here; end revetted with brus and sacks.
750- 910	432	R.	6,000	1,500	Low places topped with sacks; alo banquette repaired.
910- 940	438	R.	10,000	12,000	150 yards bagging used. (Arkansa Desha levee board work.
940-1045	439	R.			No work.
1045-1196	440	R.	12,500	4,000	Low places topped with sacks; slo paired.
1196-1510	442	R.	3,500		Do.
1510-1638	450	R.	4,500	5,000	Generally topped with teams; used s lumber.
1638-1730	450	R.	5,500	4,000	Low places topped with teams; us and lumber.
1730	451	R.	500		Spur here topped with teams.
1730-1892	451	R.	12,000	9,000	350 yards bagging; low places top teams; back slope at Carmichael with sacks and top raised.
1892-2004	467	R.	7,000	6,000	400 yards bagging; much topping with lumber, sacks, and loose eart
2004-2096	468	R.	4,000	6,250	300 yards bagging; generally topp teams; used sacks and lumber; b revetted in places with sacks.
0- 79	469	R.			Topped with teams and wheel braced with planks and sack sacked.
93	470	R.			Brush protection to prevent scour.
95	470	R.	4,000		Filled hole in slope that was scoure rent.
101	471	R.			Spur here; end protected with br sacks.
118	471	R.			Repaired hole in slope that was sco current.
168- 170	484	R.			Sacked to prevent wave wash.
222- 240	485	R.			Topped with teams.
301- 374	486	R.			Topped with teams and wheelbarrow
430- 432	487	R.			Sacked to prevent wave wash.
647	489	R.			Sand boils brushed and weighted wit
670- 685	490	R.			Crown sacked and backed with earth
714- 748	491	R.			Topped with lumber and sacks; back earth.
800- 804	493	R.			Topped with loose earth.
982-1002	496	R.			Topped with lumber, sacks, and loos banquette at Stations 988 and 995 with sacks.
1070-1081	498	R.			Topped with sacks, backed by earth.
1236-1250	503	R.			Topped with sacks.
1250-1293	503	R.	500		Topped; 500 sacks used; balance tea
1293-1387	504	R.	6,000		Topped with sacks in various places up by loose earth raised with team
1387-1406	506	R.			Topped with teams.
1406-1483	506	R.			Topped in various places, total of 2,0
1483-1516	507	R.	6,500		Topped with teams; soft places sack
1516-1577	508	R.			No work.
1577-1600	509	R.	1,000		Topped with teams; braced in fro sacks.
1820-1880	513	R.	1,000		Front revetted with brush and sacks.
1880-1919	515	R.	5,000		Topped by contractors W. M. Bates sacks used to revet soft place an hoop a boil.
1945-2004	517	R.			Topped by contractors W. M. Bates &
2008	518	R.	1,000		Hoop built around a hole running water.
2081-2090	519	R.			Topped by contractor L. C. Dresbach.
2095-2100	519	R.			Do.
0- 190	520	R.	1,200	1,000	Topped with sacks and lumber in a places.
190- 256	522	R.	5,000	10,000	Raised from 1½ to 2½ feet with sacks a ber backed by loose earth; earth river slope.
256-1090	522	R.	1,500		Sacked occasionally to prevent wave
1090-1119	535	R.	8,000	2,500	Raised from 1½ to 2½ feet with sacks a ber, backed by loose earth put on riv also.
1119-1190	535	R.	2,000		Sacked occasionally to prevent wave

Operations for high-water protection of levees, third district, etc.—Continued.

UPPER TENSAS LEVEE DISTRICT—Continued.

Stations.	Below Cairo.		Materials used.		Remarks.
	Miles.	Bank.	Sacks.	Lumber.	
Main line—Cont'd.			*Number.*	*Feet.*	
1190-1400	536	R.	3,000	1,000	Sacked in places; planked, Stations 1390-1400; loose earth dumped on river slope.
1400-1435	540	R.	3,500	1,500	Raised from 1 to 2 feet by sacks and lumber; dumped loose earth on river slope.
1435-1503	540	R.	4,000	1,000	Required little attention; wave wash checked by sacks.
1503-1570	541	R.	7,500	3,500	Raised from 1 to 2½ feet by sacks and lumber.
1570-1630	543	R.	3,500	5,000	Raised from 1½ to 2 feet by sacks and lumber, backed by loose earth.
1840	546	R.	5,000	....	3,500 yards bagging; large sand boils covered with bagging and weighted down with sacks; loose earth dumped on river slope.
1840-1985	546	R.	10,000	3,000	1,500 yards bagging; raised 2 feet in low places by sacks, bagging, lumber, and loose earth.
2236-2368	561	R.	3,000	3,500	Raised in few low places.
2411-2617	562	R.	15,000	12,000	Raised entire length by sacks and lumber; backed by loose earth put up with teams.
2810-2865	574	R.	....	15,000	2,000 yards bagging; raised 1½ feet with loose earth, protected by bagging and lumber.
2865-3031	575	R.	16,000	20,000	4,000 yards bagging; raised 2 feet with loose earth, protected by sacks, bagging and lumber.
3070-3118	578	R.	8,000	5,000	1,500 yards bagging; raised from 1 to 2 feet on short stretches with sacks, lumber, and bagging.
3118-3328	579	R.	2,000	5,000	Small amount of wave wash guarded against.
3328-3550	582	R.	30,000	30,000	3,000 yards bagging; raised 2 to 3 feet along entire length; sacks protected by bagging and lumber; lumber retaining wall built behind sacks also.
3550-3650	585	R.	2,000	2,500	Many small sloughs repaired.
3774-3905	591	R.	3,000	4,000	Short stretches raised 1 to 2 feet with sacks and lumber, backed with loose earth put up with scrapers.
3970-3998	594	R.	1,000	1,500	Raised with sacks, lumber, and loose earth.
3998-4176	595	R.	8,000	5,000	Small ridge of earth placed on top, protected by sacks and lumber; worked until Biggs break occurred, when further work was not needed.
4176-4226	597	R.	22,000	....	Raised 2 feet by sacks backed with loose earth
4409-4481	603	R.	....	....	Biggs levee, in charge of State forces.
4481-4647	604	R.	4,000	8,000	Raised from 2 to 3 feet; work mostly done by State forces; subsequently the United States protected the new topping with sacks and lumber.
Total	......	......	288,111	193,050	

RECAPITULATION.

	Sacks.	Lumber.	Bagging.
	Number.	*Feet.*	*Yards.*
Lower Yazoo district	670,100	789,000	....
Upper Tensas district	288,111	193,050	16,750
Total	958,211	982,050	16,750

NOTE.—Sections of line not mentioned needed no work of importance. In a number of cases the amounts of materials expended were not reported, so that the above totals are less than the true ones, which were about as follows:

Sacks		980,000
Lumber	feet..	1,125,000
Bagging	yards..	17,000

Labor statement, Lower Yazoo Levee district above Greenville, Miss., May 1, 1896, to 1897.

Stations.	Distance from Cairo (miles).	Contractor.	Length of contract (feet).	Cubic yards in contract.	Cubic yards in place.	Total laborers.	Total teams.	Total scrapers.	Yardage per team.	Yardage per scraper.	Price per cubic yard (cents).
0- 100	367	Ernest Hyner..	10,000	73,682	15,185	715	545	378	27.86	40.17	11.9
100- 200	369	Arnold & De Garis.........	10,000	72,284	13,940	586	358	228	38.94	61.14	11.4
200- 300	370	C. A. Winter...	10,000	60,073	33,733	1,238	939	616	35.92	54.76	12.88
300- 400	372	Ernest Hyner..	10,000	23,255	627	103	63	55	9.95	11.40	13
400- 500	374	.....do..........	10,000	59,420	15,544	588	420	295	37.01	52.68	11.5
500- 600	376	E. B. Mantle....	10,000	48,184	15,643	901	616	411	25.39	38.06	12
600- 700	377	L. C. Dulaney ..	10,000	57,065	......	......	......	......	......	......	9.23
700- 800	378	T. S. Aderholdt.	10,000	59,961	12,004	528	380	282	41.59	42.57	10.74
800- 900	378	.....do..........	10,000	87,910	......	......	......	......	......	......	10.24
900-1000	379	W. A. Shippey .	10,000	83,609	18,655	983	704	485	26.49	38.46	17.98
1200-1300	395	T. S. Aderholdt.	10,000	78,131	21,184	1,081	732	528	28.94	40.12	10.74
1300-1400	396	P. F. Lamb	10,000	62,344	......	......	......	......	......	......	12.5
1400-1500	398	Robt. Johnsen..	10,000	83,859	19,433	946	600	434	32.39	44.77	14
1500-1600	399	Ernest Hyner..	10,000	92,249	11,583	411	287	191	40.59	60.67	12
1600-1700	401	C. A. Winter...	10,000	71,444	13,806	553	371	260	37.21	53.10	10.62
1700-1800	401	J. B. Lewis.....	10,000	80 839	22,658	1,084	704	461	32.18	49.15	10.99
1800-1900	403	W. A. Shippey .	10,000	111,759	34,457	1,441	961	626	36.90	55.04	11.48
1900-2000	405	Ernest Hyner..	10,000	108,802	10,041	549	351	240	28.61	41.84	12
2000-2066	407	W. M. Bates & Co............	6,600	75,892	......	......	......	......	......	......	13

Respectfully submitted.

J. D. VAN METER, *Assistant Engi*

Labor statement, Upper Tensas Levee district above Greenville, Miss., May 1, 1896, to 1897.

Stations.	Distance from Cairo (miles).	Contractor.	Length of contract (feet).	Cubic yards in contract.	Cubic yards in place.	Total laborers.	Total teams.	Total scrapers.	Yards per team.	Yards per scraper.
0- 120	(*a*)	J. M. Whitehill........	12,000	45,000	1,473	96	59	35	25	59
798- 886	437	.....do.................	8,800	48,054	....	2,065	1,271	846	37.75	56.75
1080-1200	441	.....do.................	12,000	115,000	3,982	325	225	144	18	27.50
1510-1630	451	J. B. Lewis............	12,000	99,000	23,112	1,438	964	687	24	33.75
1630-1730	452	Arnold & De Garis....	10,000	69,000	14,438	1,151	569	375	25.5	38.50
1741-1781	453	McBain & Bro........	4,000	15,006	7,212	776	385	263	19	27.50

a Amos Bayou line.

Respectfully submitted.

H. ST. L. COPPÉE, *Assistant Engi*

Labor statement, Upper Tensas Levee district below Greenville, in Arkansas, May 1, to May 1, 1897.

Stations.	Distance from Cairo (miles).	Contractor.	Length of contract (feet).	Cubic yards in contract.	Cubic yards in place.	Total laborers.	Total teams.	Total scrapers.	Yards per team.	Yards per scraper.	Price per cubic yard (cents).	Average height
216- 388	485	Arnold & De Garis.	17,200	102,000	50,373	2,661	1,725	1,102	29.6	45.71	17.9	13
388- 462	487	C. A. Winter	7,400	52,000	17,986	1,485	912	689	19.83	26.09	22.37	14
1384-1399	506	Jas. H. Cary........	1,300	15,000	1,200	143	38	*a* 24	8.39	*a*34.21	25	16
1660-1845	510	John G. Sessions ...	18,500	84,000	26,922	933	614	452	43.84	59.67	13.33	10
1845-2010	515	W. M. Bates & Co ..	16,500	92,000	24,785	1,260	765	545	32.32	45.47	15	13
2021-2108	517	L. C. Dresbach	8,700	66,000	6,163	581	186	115	36.68	53.59	14.87	13

a Wagons.

Respectfully submitted.

E. C. TOLLINGER, *Assistant Engine*

Labor statement, Upper Tensas Levee district in Louisiana, May 1, 1896, to May 1, 1897.

Stations.	Distance from Cairo (miles).	Contractor.	Length of contract (feet).	Cubic yards in contract.	Cubic yards in place.	Total laborers.	Total teams.	Total scrapers.	Yards per team.	Yards per scraper.	Price per cubic yard (cents).	Average height (feet).	Average haul.
0-256	520	Arnold & De Garis	25,600	164,027	28,353	1,606	952	666	38	55	12.40	17	80
256-755	527	Timothy Sullivan	49,900	160,483	85,754	3,278	2,403	1,801	37	48	9.75	11.1	135
755-851	528	F. M. McLaughlin	9,500	65,948	......	......	......	......	......	......	15	......	....
851-930	529	Robert Nicholson	7,900	55,073	7,804	652	453	307	22.4	33	10.74	14.6	90
1459-1636	542	......do	17,700	94,402	31,864	1.730	1,205	842	39	44	10.44	16	90
2286-2368	560	......do	8,200	65,546	31,152	1,508	1,103	838	33	43	10.74	18.6	110
2537-2617	564	......do	9,000	23,843	23,843	1,447	1,050	715	23	33.8	8.41	2.3	110
2865-3032	575	......do	16,700	37,836	37,836	1,879	1,289	932	29	40.6	8.47	2.2	110
3364-3542	581	......do	17,800	32,736	32,736	1,466	1,082	755	30	43.3	8.47	2	110
4176-4324	600	N. I. McLeod	9,060	16,184	3,012	126	90	63	33	48	8,17	2.6	95
4323-4410	602	McLaughlin Bros	8,700	61,626	8,760	389	223	178	39	49	10.50	14.4	105
4509-4616	606	Robert Nicholson	10,700	32,794	32,794	1,639	929	617	35	53	15.91	8	110

Respectfully submitted.

W. S. BROWN, *Assistant Engineer.*

Cost of levees in Lower Yazoo Levee district, built and enlarged by the United States, from 1882 to April 30, 1897.

Year built.	Name of levee.	Built by—	Cubic yards.	Cost, including extra work.	Location on inch-to-mile map.
1882 to May 25, 1896.	Levee construction	....	6,706,447	$1,177,478.11	....
Do	High-water protection, repairs, and engineer expenses.	....	....	189,163.85	....
1895-96	Upper Buckridge	Timothy Sullivan	12,745	2,386.22	417 L.
1895-96	Lower Buckridge	.....do	16,001	2,803.98	417 L.
1896-97	Stations 0 to 100	Ernest Hyner	14,640	1,567.94	367 L.
1896-97	Stations 100 to 200	Arnold & DeGaris	11,938	1,224.84	369 L.
1896-97	Stations 200 to 300	C. A. Winter	32,240	3,735.81	370 L.
1896-97	Stations 400 to 500	Ernest Hyner	14,426	1,493.09	374 L.
1896-97	Stations 500 to 600	E. B. Mantle	15,025	1,622.70	375 L.
1896-97	Stations 700 to 800	T. S. Aderholdt	11,146	1,077.37	378 L.
1896-97	Stations 900 to 1000	W. A. Shippey	11,209	1,813.84	379 L.
1896-97	Stations 1200 to 1300	T. S. Aderholdt	17,374	1,679.37	395 L.
1896-97	Stations 1400 to 1500	Robert Johnson	17,865	2,250.99	398 L.
1896-97	Stations 1500 to 1600	Ernest Hyner	10,453	1,128.93	399 L.
1896-97	Stations 1600 to 1700	C. A. Winter	13,663	1,306.52	401 L.
1896-97	Stations 1700 to 1800	J. B. Lewis	22,281	2,203.81	401 L.
1896-97	Stations 1800 to 1900	W. A. Shippey	27,823	2,874.67	403 L.
1896-97	Stations 1900 to 2000	Ernest Hyner	7,324	790.99	405 L.
	High-water protection, repairs, and engineering expenses to Apr. 30, 1097.	....	....	81,316.59	....
	Total cubic yards to Apr. 30, 1897.	....	6,962,600	....	....
	Total cost to Apr. 30, 1897.	....	....	1,427,919.62	....

UPPER TENSAS LEVEE DISTRICT.

Cost of levees in Arkansas, built and enlarged by the United States, from 1882
30, 1897.

Year built.	Name of levee.	Built by—	Cubic yards.	Cost, including extra work.
1882 to May 25, 1896.	Levee construction		10,068,839.2	$1,631,983.09
Do	High-water protection, repairs, and engineer expenses.			332,329.96
1896–97	Banquette above Arkansas City.	J. M. Whitehill	45,316	3,419.23
1896–97	Stations 0 to 120 (Amos Bayou line).	do	1,167	131.28
1896–97	Stations 1080 to 1200	do	3,088	388.81
1896–97	Stations 1510 to 1630	J. B. Lewis	22,876	2,826.79
1896–97	Stations 1630 to 1730	Arnold & DeGaris	12,287	2,178.48
1896–97	Stations 216 to 388	do	50,082	8,068.70
1896–97	Stations 388 to 462	C. A. Winter	16,724	3,367.80
1896–97	Stations 1660 to 1845	John G. Sessions	26,350	3,161.22
1896–97	Stations 1845 to 2010	W. M. Bates & Co.	24,785	3,345.97
1896–97	Stations 2010 to 2108	L. C. Dresbach	5,329	713.42
	High-water protection, repairs, and engineering expenses to Apr. 30, 1897.			39,302.60
	Total cubic yards to Apr. 30, 1897.		10,276,843.2	
	Total cost to Apr. 30, 1897.			2,031,217.37

Cost of levees in Louisiana, built and enlarged by the United States, from 1882
30, 1897.

Year built.	Name of levee.	Built by—	Cubic yards.	Cost, including extra work.
1882 to May 25, 1896.	Levee construction		4,795,468.4	$829,946.34
Do	High-water protection, repairs, and engineer expenses.			166,305.41
1896	Stations 255 to 755 (Bunchs).	Tim. Sullivan	85,753.7	8,896.24
1896	Stations 4176 to 4325 (Delta).	N. I. McLeod	3,012	296.18
1896	Stations 4325 to 4410 (O'Brien).	McLaughlin Bros.	8,760.4	1,217.40
1896	Stations 2530 to 2620 (Salem).	Robt. Nicholson	23,842.7	2,005.17
1896	Stations 2870 to 3030 (Villa Vista).	do	37,836.3	3,204.73
1896	Stations 3365 to 3547 (Millikens Bend).	do	32,735.8	2,772.72
1896	Stations 4526 to 4620 (Reid).	do	32,794.5	5,217.60
1896–97	Stations 0 to 256	Arnold & DeGaris	28,352.6	3,164.15
1896–97	Stations 851 to 930	Robt. Nicholson	7,804.2	754.36
1896–97	Stations 1459 to 1636	do	30,864.3	2,993.97
1896–97	Stations 2286 to 2367	do	31,152.3	3,011.18
	High water protection, repairs, and engineering expenses to Apr. 30, 1897.			13,455.73
	Total cubic yards to Apr. 30, 1897.		5,118,377.2	
	Total cost to Apr. 30, 1897.			1,043,241.18

Total yardage in Upper Tensas district (Arkansas and Louisiana)........................ 15
Total cost in Upper Tensas district (Arkansas and Louisiana)........................... $3,

Linear feet revetment built, third district.

Season.	Lake Bolivar.	Ashbrook Neck.	Greenville Harbor. *a*	Louisiana Bend.	Lake Providence.	Delta Point.
1878-1881						5,400
1882-1883						1,100
1883-1884				14,250		2,200
1884-1885						2,083
1888-1889	4,250		706			
1889-1890				6,024		
1890-1891		2,820				
1891-1892		4,300	6,600	5,224		
1892-1893		2,610	4,450	5,835		
1893-1894	685					1,065
1894-1895		1,475	3,087		4,780	
1895-1896					5,360	
1896-1897			677	1,247		
Total	4,935	11,205	15,520	32,580	10,140	11,848
Repairs	685	895	2,344	1,247		3,233
Destroyed	436		706	15,233		3,565
In good order February, 1897:						
Measured on base	3,814	10,310	12,470	16,100	10,245	4,770
Measured on inner edge of mats.	3,775	9,990	*b* 12,165	15,820	10,090	5,050

a Mats between dikes not included. *b* Also about 2,900 feet protected by dikes.

Nineteen thousand two hundred and twenty-six linear feet of revetment built 1881–1884, to protect Mayersville Island, all destroyed.

Financial statement.

SURVEYS, GAUGES, AND OBSERVATIONS.

Balance June 30, 1896	$7,730.04
Expended to June 30, 1897	3,116.40
Balance June 30, 1897	4,613.64
In Treasury	4,000.00
In hand	613.64
	4,613.64
Less liabilities	1,613.64
Available balance June 30, 1897	3,000.00
Expenditures apportioned:	
Surveys	2,050.00
Steamer expenses	754.08
Outfit, material and stationery	112.13
Subsistence	114.94
Miscellaneous	85.25
Total	3,116.40
Amount that can be profitably expended during fiscal year ending June 30, 1899	10,000.00

UPPER TENSAS LEVEE DISTRICT.

Balance June 30, 1896		$63,456.86
Allotted during year	$83,750.00	
Transferred from Middle Tensas Levee district	65,272.34	
		149,022.34
		212,479.20
Expended to June 30, 1897		101,303.18
Balance June 30, 1897		111,176.02

In Treasury		$
In hand		
		1
Amount covered by existing contracts		1
Amount covered by other liabilities		
		1

No available balance June 30, 1897.

Expenditures apportioned:		
Levee construction		
Engineering and office expenses, high-water protection, and repairs		
Total		1
Amount that can be profitably expended during fiscal year ending June 30, 1899		6

MIDDLE TENSAS LEVEE DISTRICT.

Balance June 30, 1896		$
Expended to June 30, 1897		
Transferred to Upper Tensas Levee district		
		8
Expenditures apportioned:		
Levee construction		
Engineering expenses and repairs		
Total		

LOWER YAZOO LEVEE DISTRICT.

Balance June 30, 1896		$1
Allotted during year	$145,000.00	
Deposited for overpayment	.10	
		14
		16
Expended to June 30, 1897		8
Balance June 30, 1897		7
In Treasury		7
In hand		
Amount covered by existing contracts		15
Expenditures apportioned:		
Levee construction		2
Engineering and office expenses, high-water protection, and repairs		6
Total		8
Amount that can profitably be expended during fiscal year ending June 30, 1899		70

LAKE PROVIDENCE REACH.

Balance June 30, 1896		$4
Expended to June 30, 1897	$32,665.88	
Transferred to preservation of works	11,000.00	
		43
Balance June 30, 1897		
In Treasury		
In hand		
Available balance June 30, 1897		4

Expenditures apportioned:	
Labor on construction	$8,096.40
Material for construction	11,409.77
Cost and care of plant, repairs, outfit, and supplies	6,869.64
Towage and steamer expenses	1,770.80
Administration and office expenses	329.92
Subsistence	4,043.69
Miscellaneous	145.66
Total	32,665.88
Amount that can profitably be expended during fiscal year ending June 30, 1899, for maintenance	50,000.00

LAKE BOLIVAR FRONT.

Balance June 30, 1896	$97.07
Expended for stone	97.07

ASHBROOK NECK.

Balance June 30, 1896		$35,890.28
Expended to June 30, 1897	$14,880.19	
Transferred to patrolling Mississippi River	10,000.00	
		24,880.19
Balance June 30, 1897		11,010.09
In Treasury		10,000.00
In hand		1,010.09
Available balance June 30, 1897		11,010.09
Expenditures apportioned:		
Material for construction		1,660.38
Cost and care of plant and repairs		7,747.11
Towage and steamer expenses		2,712.83
Administration and office expenses		1,623.73
Subsistence		1,117.06
Miscellaneous		19.08
Total		14,880.19
Amount that can be profitably expended during fiscal year ending June 30, 1899, for maintenance		30,000.00

STONE.

Balance June 30, 1896		$23,955.24
Expended to June 30, 1897	$8,923.54	
Balance June 30, 1897	15,031.70	
		23,955.24
In Treasury		15,000.00
In hand		31.70
Available balance June 30, 1897		15,031.70
Expenditures apportioned:		
Stone		7,009.35
Cost and care of plant, repairs, outfit, and supplies		1,796.31
Administration and office expenses		27.65
Subsistence		85.23
Miscellaneous		5.00
Total		8,923.54
Amount that can profitably be expended during fiscal year ending June 30, 1899		100,000.00

PLANT.

Balance June 30, 1896		$5,
Allotted during year		7,
		12,
Expended to June 30, 1897	$12,872.35	
Balance June 30, 1897	25.44	
		12,
Available balance (in hand) June 30, 1897		

Expenditures apportioned:	
Labor on repairs	3,
Material for repairs	
Cost and care of plant, outfit, and supplies	7,
Administration and office expenses	
Subsistence	1,
Miscellaneous	
Total	12,

Amount that can be profitably expended during fiscal year ending June 30, 1899	60,

PRESERVATION OF WORKS.

Allotted during year		$30,
Expended:		
Upper Tensas Levee district	$17,066.35	
Lower Yazoo Levee district	12,933.65	
		30,

No balance June 30, 1897.

Expenditures apportioned:			
Yazoo—			
Labor	$6,941.71		
Material	5,934.66		
Telegrams and miscellaneous	57.28		
		12,933.65	
Tensas—			
Labor	9,083.24		
Material	3,001.21		
Supplies and tools	2,639.93		
Team hire	1,773.15		
Subsistence	118.98		
Telegrams and miscellaneous	449.84		
		17,066.35	
			30,

AT GREENVILLE, MISS.

Allotted during year		$64,
Expended to June 30, 1897	$16,973.31	
Balance June 30, 1897	47,026.69	
		64,
In Treasury	40,000.00	
In hand	7,026.69	
		47,

Expenditures apportioned:	
Labor on construction	8,
Material for construction	4,
Repairs to plant and supplies	
Towage and steamer expenses	1,
Subsistence	2,
Miscellaneous	
Total	16,

Amount that can be profitably expended during fiscal year ending June 30, 1899, for maintenance	100,

IMPROVING HARBOR AT VICKSBURG, MISS.

Balance June 30, 1896	$6,077.80
Expended to June 30, 1897	3,105.77
Balance June 30, 1897	2,972.03
Available balance in hand June 30, 1897	2,972.03
Expenditures apportioned:	
Cost and repairs to plant and supplies	202.52
Administration and inspection	2,903.25
Total	3,105.77

IMPROVING HARBOR AT GREENVILLE, MISS.

Balance June 30, 1896	$2,397.38
Expended for stone	2,397.38

VICKSBURG, MISS.

Balance June 30, 1896	$106.97
Expended for stone	106.97

List of civilian engineers employed on work of river and harbor improvement, in charge of Lieut. H. C. Newcomer, Corps of Engineers, from June 30, 1896, to June 30, 1897, inclusive, under the acts approved March 2, 1895, June 3, 1896, and March 31, 1897.

Name and residence.	Time employed.	Compensation per month.	Where employed.	Work on which employed.
	Mos.			
Arthur Hider, Greenville, Miss.	12	$250.00	Greenville, Miss	Care and repairs to plant; construction and repairs at Greenville, Miss., and Lake Providence, La.
F. C. Tollinger, Greenville, Miss.	12	175.00	.....do	Construction and repairs to levees in Mississippi south of Greenville and in Arkansas south of Greenville to Louisiana line.
H. St. L. Coppée, Greenville, Miss.	12	175.00	.....do	Construction and repairs of levees in Arkansas north of Greenville.
J. D. Van Meter, Greenville, Miss.	12	150.00	.....do	Construction and repairs of levees in Mississippi north of Greenville.
W. S. Brown, Lake Providence, La.	12	150.00	Lake Providence, La.	Construction and repairs of levees in Louisiana, third district.

List of contracts in force in the Lower Yazoo Levee district, with names of contractors, date of approval, of beginning work, and expiration.

Levee stations.	Below Cairo.		Contractor.	Date of approval.	Date of beginning work.	Expiration of contract.
	Miles.	Bank.				
0- 100	367	L.	Ernest Hyner	Dec. 14, 1896	Feb. 9, 1897	Oct. 1, 1897
100- 200	369	L.	Arnold & De Garis	.....do	Feb. 20, 1897	Do.
200- 300	370	L.	C. A. Winter	.....do	Dec. 9, 1896	Do.
300- 400	372	L.	Ernest Hyner	.....do	Mar. 9, 1897	Do.
400- 500	374	L.	.....do	.....do	Feb. 2, 1897	Do.
500- 600	375	L.	E. B. Mantle	.....do	Dec. 9, 1896	Do.
600- 700	377	L.	L. C. Dulaney	.....do	Not begun	Do.
700- 800	378	L.	T. S. Aderholdt	.....do	Jan. 27, 1897	Do.
800- 900	378	L.	.....do	.....do	Not begun	Do.
900-1000	379	L.	W. A. Shippey	.....do	Jan. 18, 1897	Do.
1200-1300	395	L.	T. S. Aderholdt	.....do	Dec. 18, 1896	Do.
1300-1400	396	L.	P. F. Lamb	.....do	Not begun	Do.
1400-1500	398	L.	Robt. Johnsen	.....do	Dec. 23, 1896	Do.
1500-1600	399	L.	Ernest Hyner	.....do	Feb. 1, 1897	Do.
1600-1700	401	L.	C. A. Winter	.....do	Jan. 26, 1897	Do.
1700-1800	401	L.	J. B. Lewis	.....do	Dec. 15, 1896	Do.
1800-1900	403	L.	W. A. Shippey	.....do	Jan. 16, 1897	Do.
1900-2000	405	L.	Ernest Hyner	.....do	Feb. 24, 1897	Do.
2000-2066	405	L.	W. M. Bates & Co	.....do	Not begun	Do.

List of contracts in force in the Upper Tensas Levee district, with names of c date of approval, of beginning work, and expiration.

Levee stations.	Below Cairo.		Contractor.	Date of approval.	Date of beginning work.
	Miles.	Bank.			
0- 120	(a)	....	J. M. Whitehill	Dec. 14, 1896	Feb. 26, 1897
1080-1200	441	R.	.....do	.....do	Feb. 16, 1897
1510-1630	451	R.	J. B. Lewis	.....do	Dec. 8, 1896
1630-1730	452	R.	Arnold & De Garis	.....do	Dec. 14, 1896
216- 388	485	R.	.....do	.....do	Dec. 7, 1896
388- 462	487	R.	C. A. Winter	.....do	Jan. 20, 1897
1384-1399	506	R.	Jas. H. Cary	.....do	Mar. 21, 1897
1660-1845	510	R.	John G. Sessions	.....do	Feb. 3, 1897
1845-2010	515	R.	W. M. Bates & Co	.....do	Feb. 1, 1897
2010-2108	517	R.	L. C. Dresbach	.....do	Mar. 1, 1897
0- 256	520	R.	Arnold & De Garis	.....do	Dec. 14, 1896
756- 851	528	R.	F. M. McLaughlin	Jan. 18, 1897	Not begun
851- 930	529	R.	Robert Nicholson	Dec. 14, 1896	Dec. 7, 1896
1458-1630	542	R.	.....do	.....do	.....do
2286-2367	560	R.	.....do	.....do	.....do

a Amos Bayou line.

Abstract of proposals for levee work in Lower Yazoo Levee district received and First Lieut. H. C. Newcomer, Corps of Engineers, November 7, 1896.

[All bids rejected and new proposals invited, to be opened November 23, 1896.]

No.	Name of bidder.	Stations 0 to 100 (367 L).	Stations 100 to 200 (369 L).	Stations 200 to 300 (370 L).	Stations 300 to 400 (372 L).	Stations 400 to 500 (374 L).	Stations 500 to 600 (376 L).	Stations 600 to 700 (377 L).	Stations 700 to 800 (378 L).
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Timothy Sullivan	17.98	17.98	17.98	17.98	17.98	17.98	17.98	17.98
2	T. S. Aderholdt	15	15	15	17	14.7	13.74	13.24	12.24
3	J. B. Lewis	......	......	......	......	14.94	15	12.73	12.65
4	P. F. Lamb	......	......	......	......	......	18	14.45	17.5
6	Robt. Johnsen	14.5	14.23	13.99	15.16⅔	14.5	14.5	14.25	14.25
7	J. S. McTighe & Co	16	16	20	19	17	16	13.5	20
9	Arnold & De Garis	15	14	15.5	......	16.25	15.5	14.75	18.25
10	McCadden & Co	14.5	13.9375	11.9375	......	......	......	10.9375	......
11	Ben Talley	15	16	16.25	......	13	......	15.9	......
12	L. C. Dresbach & Co	14.125	14.125	13.47	......	......	......	......	12
18	Jas. H. Cary	13	14	15	15	15	13	13	15
20	C. A. Winter	......	......	15	......	......	......	13.875	......

No.	Name of bidder.	Stations 1000 to 1100 (380 L).	Stations 1100 to 1200 (393 L).	Stations 1200 to 1300 (395 L).	Stations 1300 to 1400 (396 L).	Stations 1400 to 1500 (398 L).	Stations 1500 to 1600 (399 L).	Stations 1600 to 1700 (401 L).	Stations 1700 to 1800 (401 L).	Stations 1800 to 1900 (403 L).
		Cts.	*Cents.*	*Cents.*	*Cents.*	*Cts.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Timothy Sullivan	39	39	39	39	39	35	35	35	35
2	T. S. Aderholdt	.....	......	13	16	16	17	16	15	16
3	J. B. Lewis	29	28	15.25	16	24.5	15.67	13	12.74	14.7
5	W. A. Shippey	.....	......	......	......	.....	......	......	......	.....
6	Robt. Johnsen	16.5	25.5	14.5	15	16.5	14.5	13.99	14.5	15.5
7	J. S. McTighe & Co	28	30	17	15	18	13	16	14	17
9	Arnold & De Garis	.....	23.5	15	15.5	.....	14.25	13.5	14.75	15.5
10	McCadden & Co	.....	......	10.74	......	.....	......	11.9375	11.9375	.....
11	Ben Talley	.....	......	......	16.25	19	......	14.9	......	.....
12	L. C. Dresbach & Co	.....	......	14.46	......	.....	......	15	......	.....
13	H. F. Watkins	.....	......	......	......	.....	14.9	13.2	14.2	16.44
16	Loonan & McLeod	.....	......	......	......	.....	14.4	11.47	12.89	.....
18	Jas. H. Cary	25	30	13	19	18	15.5	14	16	.....
20	C. A. Winter	.....	26.125	......	......	.....	......	14.125	15.125	.....

Abstract of proposals for levee work in Upper Tensas Levee district received and opened by First Lieut. H. C. Newcomer, Corps of Engineers, November 7, 1896.

[All bids rejected and new proposals invited, to be opened November 23, 1896.]

No.	Name of bidder.	Amos Bayou line.	Mississippi River levees above Greenville.			Mississippi River levees below Greenville.					
		Stations 0 to 120.	Stations 1080 to 1200 (441 R).	Stations 1510 to 1630 (451 R).	Stations 1630 to 1730 (452 R).	Stations 216 to 388 (485 R).	Stations 388 to 462 (487 R).	Stations 1384 to 1399 (500 R).	Stations 1660 to 1845 (510 R).	Stations 1845 to 2010 (515 R).	Stations 2010 to 2108 (517 R).
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Timothy Sullivan		50	50	50	30	30	30	30	30	30
2	T. S. Aderholdt			18	23						
3	J. B. Lewis	26.7					33.333	39	23		
6	Robt. Johnsen	24.75									
7	Arnold & De Garis	22.75	19	20	24.75	21	28.5		19	16.5	16
15	K. H. Killebrew & Co.	16				19			13.9		
17	Manning & Gibson								17		
19	Wm. M. Forrest	25	26								

Abstract of proposals for levee work in the Middle Tensas Levee district received and opened by First Lieut. H. C. Newcomer, Corps of Engineers, November 7, 1896.

[All bids rejected and new proposals invited, to be opened November 23, 1896.]

No.	Name of bidder.	Stations 0 to 256 (520 R).	Stations 756 to 851 (528 R).	Stations 851 to 930 (529 R).	Stations 1159 to 1636 (542 R).	Stations 2286 to 2367 (560 R).
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Timothy Sullivan	22	30	18	20	18
8	Robt. Nicholson				13.91	14.91
9	Arnold & De Garis	14	18	15		
14	Jno. C. Hodge	22.5		12.5	10.99	
18	Jas. H. Cary	15				

Abstract of proposals for levee work in Lower Yazoo Levee district received and opened by First Lieut. H. C. Newcomer, Corps of Engineers, November 23, 1896.

No.	Name of bidder.	Stations 0 to 100 (367 L).	Stations 100 to 200 (369 L).	Stations 200 to 300 (370 L).	Stations 300 to 400 (372 L).	Stations 400 to 500 (374 L).	Stations 500 to 600 (376 L).	Stations 600 to 700 (377 L).	Stations 700 to 800 (378 L).	Stations 800 to 900 (378 L).	Stations 900 to 1000 (379 L).
		Cts.	*Cts.*	*Cents.*	*Cts.*	*Cts.*	*Cts.*	*Cents.*	*Cents.*	*Cents.*	*Cts.*
2	M. J. Roach						13.74	9.88	10.9	13.9	
4	Ernest Hyner	[a]11.9	12.9	16	[a]13	[a]11.5		12	12	13	18
6	Jas. H. Cary	14	14	14	15	14	14	14.5	13.5	14	21.5
7	W. A. Shippey								11.5		[a]17.98
8	T. S. Aderholdt	14	14	13	13.9	13.5	12.5	11.24	[a]10.74	[a]10.24	
9	Bobbitt & O'Brien	16	16	15		13.74	16.45	12.5	12.375	14.5	25
10	L. C. Dresbach	12.73	13.98	13			16	16	13	14.875	
11	J. B. Lewis					12.93	12.93	11.73	10.93	13.99	19.95
13	E. B. Mantle	12.5				12.45	[a]12	12.45	11.9		
14	H. F. Watkins	16	16	14	18	12.2	12.94	12.94	16	13.2	21.45
15	Robt. Johnsen	14	13.74	14	15.5	13.5	12.5	11	12	12	21
16	Arnold & De Garis	12.9	[a]11.4	12.9	16	14.3	13.5	12.5	14.9	17.3	21
17	W. M. Bates & Co	12.5	13	13	13.5	13	13.5	12	12	12	22
18	L. C. Dulaney							[a]9.23			
19	N. I. McLeod					12.97		10.37	10.9		
21	Ben Talley	12.5	12.5	14.45		13		12.45			
24	P. F. Lamb							10.45	12.25	15	19
25	F. M. McLaughlin				14.75	20	14	12.5	20	20	30
26	Tim Sullivan	12.95	12.95	15	16	14.5	13.25	13	12.5	12.5	23.5
27	C. A. Winter			[a]12.875				10.875			

[a] Accepted.

Abstract of proposals for the levee work in Lower Yazoo district—Continued

No.	Name of bidder.	Stations 1000 to 1100 (380 L.).	Stations 1100 to 1200 (393 L.).	Stations 1200 to 1300 (395 L.).	Stations 1300 to 1400 (396 L.).	Stations 1400 to 1500 (398 L.).	Stations 1500 to 1600 (399 L.).	Stations 1600 to 1700 (401 L.).	Stations 1700 to 1800 (401 L.).	Stations 1800 to 1900 (403 L.).	Stations 1900 to 2000 (40
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cen*
4	Ernest Hyner	21.9	21.9	12	13		[a]12	11.9	13	15	[a]12
6	Jas. H. Cary	23	22	13.5	15	16.5	14.75	13.5	14.5	15	15
7	W. A. Shippey	17.98	17.98					10.98	14.5	[a]11.48	12.
8	T. S. Aderholdt			[a]10.74	16	16	17	16	16	14.5	13.
9	Bobbitt & O'Brien	26	26	12.73	17	16	14	12.5	13	14	14.
10	L. C. Dresbach			14	16				12.625		
11	J. B. Lewis	23	21.5	12.93	14.37	17	13.5	11.2	[a]10.99	12.93	13.
14	H. F. Watkins	24.45	24.45	14.7	14.7	15.7	13	11	12	13.2	12.
15	Robt. Johnsen	21	20.5	12	15.5	[a]14	12.25	10.98	12	14	14
16	Arnold & De Garis	20	22.9	18.2	13.9	19.2	12.6	12.1	12.9	13.6	15.
17	W. M. Bates & Co.	23	22	12.5	14	15.5	12.5	12	12.5	14	12
18	L. C. Dulaney				13.24			10.97			
21	Ben Talley		22	12.99			12.45				
23	H. J. Loonan							11.5			
24	P. F. Lamb				[a]12.5				13.79		
25	F. M. McLaughlin	25	30	25	18	23	15.5		16	18	22
26	Timothy Sullivan	23.5	26	13.5	13.75	19.75	13.75	13.5	18.5	13.5	18.
27	C. A. Winter		22.125					[a]10.625	12.4		
28	Kennedy & Tracy						15.49	21.5			

[a] Accepted.

Abstract of proposals for levee work in Upper Tensas Levee district received an by First Lieut. H. C. Newcomer, Corps of Engineers, November 23, 1896.

No.	Name of bidder.	Amos Bayou line, 0 to 120.	Mississippi River levees above Greenville.			Mississippi River levees below ville.				
			1080 to 1200 (441 R.).	1510 to 1630 (451 R.).	1630 to 1730 (452 R.).	216 to 388 (485 R.).	388 to 462 (487 R.).	1384 to 1399 (506 R.).	1660 to 1845 (510 R.).	1845 to 2010
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cent*
1	John C. Hodge								16.25	18
3	J. M. Whitehill	[a]12.5	[a]13.99							
4	Ernest Hyner			15.44				31		
6	Jas. H. Cary				21.75		24.5	[a]25		
7	W. A. Shippey	18.5								
8	T. S. Aderholdt			17.24	21.24					
10	L. C. Dresbach					18				
11	J. B. Lewis	14.75	18.25	[a]13.73	20	17.92	24.7	28.5	14.9	
12	Manning & Gibson								14.99	
15	Robt. Johnsen	20.75								
16	Arnold & De Garis	19.9	18.2	16.4	[a]19.7	[a]17.9	24.7	33.333	16.9	15.2
17	W. M. Bates & Co.	22	18.5	20	25	18.5	27	29.5	15	[a]15
20	John G. Sessions								[a]13.33	13.7
22	Wm. M. Forrest	17	16							
25	F. M. McLaughlin					35	25		14	18
26	Timothy Sullivan		18.9						13.46	15.2
27	C. A. Winter			15.375	19.98	23	[a]22.375	29.75	16.97	18
28	Kennedy & Tracy			15.49	21.5					

[a] Accepted.

Abstract of proposals for levee work in the Middle Tensas Levee district received and opened by First Lieut. H. C. Newcomer, Corps of Engineers, November 23, 1896.

No.	Name of bidder.	Stations 0 to 256 (520 R).	Stations 756 to 851 (528 R).	Stations 851 to 930 (529 R).	Stations 1459 to 1636 (542 R).	Stations 2286 to 2367 (560 R).
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	John C. Hodge	14.5	16.5	12.5	12.5	....
5	Robt. Nicholson	13.21	16.91	*a* 10.74	*a* 10.44	*a* 10.74
6	Jas. H. Cary	13	....	....	....	....
10	L. C. Dresbach	12.78	....	....	....	....
12	Manning & Gibson	....	....	17.99	....	....
16	Arnold & De Garis	*a* 12.4	16.4	13.2	12.9	12.2
17	W. B. Bates & Co	13.5	17	12	11.75	13
20	John G. Sessions	14.7	....	17	19.25	....
25	F. M. McLaughlin	13.75	*a* 15	11.75	10.5	12
26	Timothy Sullivan	14.24	17.74	11.22	12.42	13.98

a Accepted.

APPENDIX 10.

REPORT OF CAPT. G. M'C. DERBY, CORPS OF ENGINEERS, UPON OPERATIONS IN THE FOURTH DISTRICT.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., June 1, 1897.

COLONEL: I have the honor to submit the following report upon the work of the Fourth district, Mississippi River improvement, for the period from May 1, 1896, to May 1, 1897.

Pursuant to the requirements of Special Order 207, Adjutant General's Office, 1896, First Lieut. Charles S. Riché was relieved from duty under my immediate orders September 15, 1896; and in compliance with Special Orders 208, Adjutant General's Office, 1896, Additional Second Lieut. George M. Hoffman reported to me for duty October 1, 1896. Orders have been received for the relief of Lieutenant Hoffman, to take effect June 10, 1897.

The Fourth district, Mississippi River improvement, extends from Warrenton, 7½ miles below Vicksburg, to the Head of the Passes, about 13 miles from the Gulf of Mexico, a distance of 452.8 miles by river.

The works include improvements of the harbor of Natchez and Vidalia, Mississippi and Louisiana; improvements at the junction of the Mississippi, Red, and Atchafalaya rivers; improvement of the harbor of New Orleans; the dredging of a channel across a bar in the Mississippi River at Ford's; and the construction, repair, and maintenance of a portion of the levee system of the district.

HARBOR AT NATCHEZ AND VIDALIA.

The rapid caving of the bank in Giles Bend above Natchez has narrowed the adjacent neck so that there is danger that the river may break through and form a permanent cut-off. Should such a cut-off take place, it is probable that it would result in the destruction of the town of Vidalia, injury to the water front and landings at Natchez, and increased caving of the banks for many miles above and below the cut-off, with consequent destruction of expensive parts of the levee system.

The object of the proposed work is to prevent the formation of the threatened cut-off. The project contemplates the construction of a levee on or near the axis of Cowpen Neck to prevent the flow of water across the neck during high stages of the river, and the construction of 16,000 linear feet of bank revetment in Giles Bend; estimated cost, $541,300.

The amount expended upon this project to date of last report, May 1, 1896, was $94,893.98, and there remained available a balance of $73,358.06. The levee on Cowpen Neck had been constructed, ten new barges had been purchased, and the delivery of rock for the revetment work had begun.

During the past year a contract was made for enlarging the levee on Cowpen Neck to a grade of 5 feet above high water. This work was about half completed when interrupted by the rapidly rising river. About 5,000 tons of rock have been purchased and received for the contemplated revetment in Giles Bend. A small quantity of it has been used in paving the end of the Cowpen Neck levee and the balance stored on the river bank in the vicinity.

At the request of the owner of the land a syphon has been placed across
at Shilling's Bayou, to make good the drainage interrupted by the constru
the levee.

All of the plant of the district having been in use at New Orleans Harbo
the past season, work has not yet been begun on the revetment at Gil
Contracts are now being made preparatory to beginning the revetment abou

The following project for this work was submitted March 16, and approve
30, 1897:

* * * * * *

"This project was not submitted with the other projects under the act o
because the plant of this district is not sufficient to carry on works of ban
tion at more than one point at a time, and the work at New Orleans Harb
more urgent, I thought it best not to decide upon the form of bank pro
would recommend for Natchez and Vidalia until I had gotten the bene
season's work at New Orleans, particularly as it was intended to introd
changes in methods which were more or less experimental.

"The work at New Orleans has now come to a close after a particularly s
season, during which the changes in the methods of construction have r
thorough test, and I feel justified in recommending the application of
methods at Natchez and Vidalia.

"The most valuable of these changes, due to a suggestion from my assis
H. S. Douglas, has consisted in the construction of mats and cribs at th
grounds and towing them, when completed, to the bank to be protected, i
constructing them at the latter locality, as heretofore. The finished mats
for New Orleans Harbor were successfully and economically towed last sea
tance of 150 miles.

"Interesting experiments are now in progress with a view to making so
rial much more economical than rock for sinking the mats and cribs, using
the sand and clay found upon the banks of the river where these structur
be sunk. These experiments so far give great promise of success.

"The reduction in the cost of crib and mat construction secured this sea
other no less important economies in sight, coupled with the fact that th
systems of spur dykes in New Orleans Harbor have, in the main, been suc
holding the banks protected and that in no case have any spurs been actua
in need of excessive repairs, has satisfied me that at the present state o
of bank protection the most available method for Natchez and Vidalia is
dike system.

"The upper spur should be located at a point where the bank has little
dency to cave, and a sufficient sum of money should be held in reserve t
this spur from being flanked by the current, should any change in the r
the river occur which might cause such a tendency.

"Owing to the tendency of the point of caving to work down stream a
the proximity of the bluff and the presence of a bed of indurated sandy
the foot of the bluff, which yields but slightly to the action of the current,
pate no serious difficulty in holding the upper spur of the system, th
works should never be left without a balance of ready money, which
applied to protecting this crucial point against any unforeseen attack.

"It is proposed to place the spurs at intervals of 450 feet, standing each
a foundation mat 150 feet wide. This interval is about what experience has
at New Orleans, and it makes the length of bank, not directly protected by
just twice as great as the portion that is.

"The foundation mat will be of the usual New Orleans type, 2½ feet thic
to extend from the low-water mark to a point on the bottom of the rive
beyond the foot of the slope. On the average this will require a mat 300

"The spurs will be built of two cribs, each 6 feet thick. The upper one
wide, to extend from near low-water mark to the foot of the slope. And t
one, 24 feet wide, to fill in the hollow of the curve of the bank in the us
This will not in all cases bring the top of the spur to a slope of 1 on 3, b
judgment it is not necessary that it should, and if further experience shoul
any necessity for doing so, a third crib can at any time be added where req

"It is proposed to sink the mats and cribs with stone, or with any suit
stitute which the experiments now in progress may develop as having
weight, permanence, and ability to resist erosion. The estimates below
upon the use of stone.

"As the slope of the bank is generally quite gradual in Giles Bend, wh
spurs are to be constructed, and the range of the river amounts to about 5
will be necessary to adopt some form of construction to protect the bank
high and low water, mats and cribs not being suitable, as they would rapidl

Earthen embankments revetted with stone have been tried for this purpose at New Orleans but have not proven satisfactory.

"In my judgment what is required in this instance is a type of structure which will check the velocity of the current in contact with the bank, but without stopping it altogether. By this means I should hope to prevent the formation of large eddies.

"With this end in view I would propose to grade the bank on the prolongation of the axis of the spur, and on the slope so formed drive a line of 12 or 14 inch piles, about 6 inches apart, in prolongation of the spur, cutting them off at a height of 12 feet above the ground, and bolting their heads firmly to a couple of string pieces. To prevent the small eddies and rapid currents which will be formed between and around the piles from cutting away the bottom in the immediate vicinity, it is proposed to pave the bank with stone for a distance of 25 feet above and below each pile dike.

"The average field cost of each spur, including the shore connection, will only amount to $5,500; assuming that each spur protects 450 feet of bank, this protection is only estimated to cost $12.20 per running foot of bank, no allowance being made, however, for the cost of the plant, as this item has usually been omitted in such estimates.

"I transmit herewith a map of the most recent survey of Giles Bend, showing in a general way the location of the proposed spurs; the changes in the bank at this locality are so rapid, however, that the exact location of the spurs can not be definitely determined until they are about to be constructed.

Estimate.

Constructing 14 spurs, at $5,500	$77,000
Reserve for protecting threatened spurs	5,000
Care and maintenance of plant	5,000
Administration	8,700
Total	95,700

Funds available.

Appropriation of June 3, 1896	64,000
Available balance of previous appropriations	31,700
Total	95,700

"It is proposed to do the work by hired labor, this method being in this instance the most economical and advantageous to the Government."

* * * * * * *

The caving in Giles Bend still continues at a rapid rate, as shown on the accompanying sketch. If it is allowed to continue, the cut-off will not only do all the damage originally anticipated, but the new levee on Cowpen Neck will be destroyed and all the money heretofore appropriated for that project, amounting to $232,252.04, will be wasted. If it is intended to prevent the cut-off, prompt and energetic measures are necessary.

The amount which can be profitably expended during the fiscal year ending June 30, 1899, is $317,300, the balance of the estimate. If this amount can not be appropriated at once, an important saving in the cost of the work could still be secured by placing it under the continuing contract system.

The amount expended from June 30, 1896, to June 30, 1897, is $24,843.04, distributed as follows:

Office expenses (main office)	$929.29
Other administrative expenses	1,725.59
Material for construction	8,832.98
Construction of levee	3,642.45
Construction (hired labor) wages	765.93
High-water protection	1,728.54
Surveys	83.83
Repairs to plant	5,952.13
Care of plant	661.60
New plant	147.07
Miscellaneous	373.63
Total	24,843.04

Money statement.

IMPROVING HARBORS AT NATCHEZ AND VIDALIA, MISSISSIPPI AND LOUI

July 1, 1896, balance unexpended		$1
Amount appropriated by act of June 4, 1897		1
		2
June 30, 1897, amount expended during fiscal year		
July 1, 1897, balance unexpended		2
July 1, 1897, outstanding liabilities	$1,100.00	
July 1, 1897, amount covered by uncompleted contracts	15,378.31	
July 1, 1897, balance available		2
Amount that can be profitably expended in fiscal year ending June 30, 1899		3

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

JUNCTION OF THE MISSISSIPPI, RED, AND ATCHAFALAYA RIVERS, LOUIS

A detailed description of the difficulties in this vicinity which the impr
are destined to rectify will be found in the Annual Report of 1892. In gene
these difficulties consist in the silting up of Old River, the only navigable co
between the Mississippi and the Red and Atchafalaya rivers, so that l
navigation is impeded and at times entirely interrupted.

The entire Red and Atchafalaya system, whose only outlet is now thr
channels which these works are destined to improve, comprises a total
about 4,300 miles of navigable river when the rivers are a few feet above
water stage. At low water the navigable portion of the Red and Atchafalay
is about 345 miles for a 3-foot draft and 132 miles for a 5-foot draft.

The works contemplated have in view the following objects:

To check the enlargement of the Atchafalaya and limit its outlet capa
system of low relief dams or sills.

To separate the Red from the Atchafalaya during low water and up to
stage by means of a low dam at the west end of Turnbull Island, which wou
the Red around the upper side of the island.

To supply a new outlet for the Red by cutting a canal across Carrs I
obstructing the lower end of upper Old River.

The Red would thus always be a tributary of the Mississippi at low stage
Atchafalaya an outlet, while the conditions at high stages would remain a
same as they were originally.

The plan also contemplates maintaining low-water navigation through l
River, if practicable, by dredging or otherwise, pending the completion of t
system of works.

At the date of the last annual report the following work had been done:

Two sill dams near the head of the Atchafalaya, with shore protection, co
levees and wing levees had been completed. The sill or foot mattresses an
protection work of the Red River Dam had been finished, and the dam had
structed to a height of 3 feet above the zero of Barbre's gauge, excepting
of 450 feet for the accommodation of low-water navigation, which was 5 fe
the zero of Barbre's gauge. An hydraulic dredge had been built, and
seasons navigation through lower Old River had been kept open continu
dredging.

On June 19, 1896, I submitted to the Commission a project for this seaso
as follows:

* * * * * *

"The Mississippi River Commission have heretofore decided that it wou
practicable to continue work under the adopted project for the permanent
ment of the junction of the Red and Atchafalaya rivers until the funds
amount to at least $300,000. I know no reason for changing this conclusion
only alternative is to continue to maintain the channel through lower O
with the dredge.

"The two sills in the Atchafalaya River are in good condition, and re
immediate repairs. Nor does there appear to be any immediate necessity for

ing the number of these sills, as the Atchafalaya has shown of recent years no alarming tendency to enlarge.

"The dam across Red River at Turnbulls Island is in a critical condition, and if it is intended to maintain this dam it will require extensive repairs this season. This dam forms part of the adopted project for the permanent improvement of the junction of the Red and Atchafalaya rivers, and if this project is to be carried out the dam should be maintained; otherwise, as it serves no useful purpose, it would be well to abandon it altogether. Unless some change in conditions arises tending to increase the cost of maintaining the channel through lower Old River with the dredge, as has been done for the past two years, I am of the opinion that it would be well to abandon the project for permanent improvement, as the cost of dredging is now less than the interest on the first cost of the permanent works plus the cost of maintaining them, and the present indications are that the cost of dredging will be further reduced this year.

"The principal element of uncertainty in this question at present is the effect of high water upon the dredged channel in lower Old River, and this effect is not yet known for this season's high water. I therefore submit no project for the repair of the Red River Dam, and unless otherwise instructed shall not do so unless it should be found, when the present high water subsides, that the dredged channel has suffered much more than it did the year before."

* * * * * * *

On the subsidence of the high water an examination was made of the channel through Old River; little or no deterioration had occurred, except the usual shoaling on the bar at the mouth.

The high water had, however, been a very moderate one, the river having only reached a stage of 35.8 feet on the gauge at Barbres Landing, which is somewhat less than a bank-full stage. Such a stage of the river throws no light on the probable effect of ordinary high water upon the cost of maintaining the channel with the dredge, which therefore remains an uncertainty as heretofore.

A careful examination was made at low water in the neighborhood of the sill dams near the head of the Atchafalaya; they were found in good order, little or no settling having occurred since last examination, and the danger of undermining having been greatly reduced by an extensive shoaling of the river amounting very generally to as much as 10 feet. This shoaling is to be accounted for by the fact that the low-water stage of the Mississippi River was extraordinarily high throughout the season; this caused a strong current from the Mississippi River through Old River, which carried into the Atchafalaya vast quantities of mud and sand which were deposited on reaching the comparative slack current in the Atchafalaya. This current persisted without reversal for one hundred and ninety-two days, which is a very unusual occurrence.

No examination was made of the Red River Dam at Turnbulls Island, as the condition of the channel in Old River did not indicate that the cost of repairs would be justifiable.

For the reasons set forth, the work of the current fiscal year has been confined to dredging Old River.

The gauge at Red River Landing reading 12.67 on August 31, with a falling river, the dredge *Ram* was sent to the mouth of Old River, where she began dredging on October 3. It is estimated that 11,570 cubic yards of material were dredged, and deposited in the stream alongside the cut made by the dredge.

The gauge at Red River Landing did not fall below 3.8 feet during the season, and the channel was dredged for a navigable depth of 5¼ feet at extreme low water. The light-draft boats, which are able to navigate the rivers having their outlet through Old River, do not require a depth of more than 5½ feet, so navigation was maintained throughout the low-water season without interruption. This result cost $2,320.40 as compared with $8,333.19 last year and $19,304.29 the year before.

For further details of the work accomplished during the year reference is made to the report of Mr. A. F. Woolley, assistant engineer, herewith.

The amount expended from June 30, 1896, to June 30, 1897, is $12,739.30, distributed as follows:

Office expenses (main office)	$3,024.68
Other administrative expenses	1,720.63
Dredging Old River	2,320.40
Repair and maintenance of telephone line	60.00
Surveys	90.63
Repairs to plant	2,673.62
Care of plant	2,321.94
New plant	527.40
Total	12,739.30

Money statement.

IMPROVING ATCHAFALAYA AND RED RIVERS, LOUISIANA.

July 1, 1896, balance unexpended..................................
June 30, 1897, amount expended during fiscal year..................

July 1, 1897, balance unexpended..................................
July 1, 1897, outstanding liabilities...............................

July 1, 1897, balance available....................................

{Amount that can be profitably expended in fiscal year ending June 30,18
{Submitted in compliance with requirements of sections 2 of river a
{ harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

NEW ORLEANS HARBOR.

The general object of the improvement of New Orleans Harbor is t
caving of the banks of the river within the limits of the harbor.

Under the approved project the work to accomplish this object c
construction of submerged inclined spur dikes, with mattress revetn
these dikes when found necessary.

At the date of the last annual report the following work had been
general accordance with the project above outlined: A mattress 400 f
had been placed just above the caving bank in Carrollton Bend. Fi
with continuous revetment covering the three upper intervals and so
than one-third of the lower one, had been built in the Carrollton Be
dikes in the Greenville Bend; six in the Gouldsboro Bend. In the T
Reach eight spur dikes had been completed, the foundation mattress h
for four others, and mattress revetment had been constructed betwee
and 2, a distance of 1,020 feet, and in some of the other intervals betw

At the date of the last annual report revetment work had been s
account of lack of sufficient funds; but by the act of June 3, 1896, an
of $110,000 was made for this harbor, and work was immediately resun

The work accomplished during the year has consisted in the comp
spurs in the Third District Reach, known as 2¼′, 3½′, 4′, and 4½′, founda
which had been laid two years ago, and in constructing four new s
reduce to one-half the intervals between spurs 5′, 1, 2, 3, and 4. The a
sketch shows the progress of the work.

An important reduction has been made this year in the cost of crib
construction. One hundred and ninety-two thousand square feet of
constructed and sunk at a cost of 6.17 cents per square foot and 606,72
crib work at 2.95 cents per cubic foot. This represents a reduction of
cent in the cost of the work, much of which is to be attributed to the
ment of my assistants, Lieut. Charles S. Riché, Corps of Engineers, a
Douglas. I expect to secure a further important economy in the exe
work by introducing some substitute for the stone used in sinking
cribs, which now constitutes one of the principal items of expense, th
to have for its base the sand and clay found upon the banks of the riv
revetment is to be built.

The details of this season's work are very fully set forth in the accomp
of Mr. H. S. Douglas, assistant engineer, to which attention is respectfu

To secure economy in the management of this work, regular appropr
less than $200,000 per annum are necessary. In this connection it is to
that floating plant, consisting of wooden barges and steamboats, dete
rapidly in this climate, and this action goes on just as rapidly when th
as when it is at work. There are other heavy expenses, for watchmen
tendence, that can not be avoided when the plant is idle, so that the cos
done in New Orleans is greatly increased by the irregularity and inade
appropriations.

The amount that can be profitably expended during the fiscal year
30, 1899, is $300,000. If this amount can not be appropriated at once,
saving in the cost of the work could still be secured by placing it un
tinuing contract system, which would enable the engineer in charge t
and carry on the work systematically. This can hardly be done when
priations are made some years and there is no certainty as to whether
any at all for the next year.

The amount expended from June 30, 1896, to June 30, 1897, is $62,777.25, distributed as follows:

Office expenses (main office)	$3,171.01
Other administrative expenses	5,194.39
Material for construction	14,847.04
Labor on construction	15,916.80
Subsistence	5,157.65
Surveys	257.20
Repairs to plant	12,699.17
Care of plant	3,093.85
New plant	2,440.14
Total	62,777.25

Money statement.

IMPROVING HARBOR AT NEW ORLEANS, LA.

July 1, 1896, balance unexpended	$120,684.55
June 30, 1897, amount expended during fiscal year	62,777.25
July 1, 1897, balance unexpended	57,907.30
July 1, 1897, outstanding liabilities	350.00
July 1, 1897, balance available	57,557.30
Amount that can be profitably expended in fiscal year ending June 30, 1899 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	300,000.00

DREDGING (FORDS CROSSING).

Under authority of a resolution of the Mississippi River Commission of November 19, 1895, the dredge *Ram* was moved to Fords Crossing during the low-water season as soon as she could be spared from the mouth of Old River.

A survey was made and a channel laid out as shown on the sketch herewith. The best water on the bar was 6.4 feet below extreme low water.

Actual dredging was begun on September 28 and continued until October 22. A channel 1,900 feet long and 100 feet wide, with a depth of 12 feet below extreme low water, was obtained.

The river at Fords Crossing fell to its lowest point on September 26, which was 5 feet higher than extreme low water. No difficulty of navigation was experienced.

The amount expended from June 30, 1896, to June 30, 1897, is $1,964.81, distributed as follows:

Administrative expenses	$465.00
Subsistence	362.23
Hired labor	992.08
New plant	145.50
Total	1,964.81

Money statement.

DREDGES AND DREDGING.

Amount allotted	$1,964.81
June 30, 1897, amount expended during fiscal year	1,964.81

SURVEYS, GAUGES, AND OBSERVATIONS.

Very little work of this character has been done during the past year. Comparative sections of the Mississippi River were sounded at Red River Landing, Carrollton, and Pointe a la Hache in compliance with a resolution of the Mississippi River Commission. A survey of the channel at Fords Crossing was made in the month of September for the purpose of determining what work would be necessary to secure a navigable channel during the then approaching low water.

Soundings have also been taken over the sill dams in the Atchafalaya River to determine their condition and the gauge at Barbres Landing, at the junction of the Red and Atchafalaya rivers, has been maintained as heretofore.

The amount expended from June 30, 1896, to June 30, 1897, is $
as follows:

Office expenses (main office)..
Other administrative expenses ....
Field work and drafting ....
Subsistence ....
Repairs to plant ....
Care of plant ....
New plant. ....

Total ....

Money statement.

SURVEYS, GAUGES, AND OBSERVATIONS.

July 1, 1896, balance unexpended...
June 30, 1897, amount expended during fiscal year..................

July 1, 1897, balance unexpended...

{ Amount that can be profitably expended in fiscal year ending Jun
{ Submitted in compliance with requirements of sections 2 of r
{ harbor acts of 1866 and 1867 and of sundry civil act of June

LEVEES.

For work connected with levee construction and maintenance
divided into seven levee districts, as follows:
The Lower Tensas Levee district, right bank, which extends fr
of the fourth district, opposite Warrenton, to the mouth of Red
trict the levee system is continuous from the upper end to a p
Fairview Landing, 131.5 miles by river, leaving about 26 miles u
The Atchafalaya Levee district, right bank, which extends fro
River to the head of Bayou Lafourche, a distance of 122 miles b
system is continuous in this district.
The Lafourche Levee district, right bank, which extends from
Lafourche to New Orleans. The distance by river is 78 miles, a
is continuous.
The Barataria Levee district, right bank, which extends from
Head of the Passes, 82½ miles. The levee system is continuous
71.5 miles.
The Homochitto Levee district, left bank, created by a resolutio
River Commission, November 19, 1894, which extends from the
River to Baton Rouge, 238.5 miles by river. There are as yet n
trict except a few detached lengths built by private parties.
The Pontchartrain Levee district, left bank, which extends fr
New Orleans, 123.5 miles. The levees are continuous.
The Lake Borgne Levee district, left bank, which extends fr
the Head of the Passes, 91 miles. The levee system at present o
St. Philip, covering 70 miles of the river.
Attention is invited to the accompanying reports of Mr. W.
engineer, and Mr. H. B. Watson, surveyor.
The levees in this district have been built, wholly or in part, b
the levee boards of the various levee districts, by the State of
the United States.
The first levees built by the United States were constructed in
the last annual report the work done by the Federal Governme
trict amounted to 17,977,188 cubic yards, resulting in the United
structed, in whole or in part, 52 per cent of the total effective leng
The funds available for levee construction in this district Ma
to $159,292.84. This amount was subsequently increased to $271
ments made June 22 from the appropriation of June 3, 1896.
The contracts for levee construction awarded during the year co
amount to 1,774,830 cubic yards at an average contract price of
pared with 4,658,342 cubic yards at 10.3 cents for the preceding
in cost is due to the comparatively small amount of work done an
small amount happened to be in localities where the work is alw
than the average.
No work has been done in the Homochitto Levee district, th
funds available.
The details of the work accomplished during the year in th
given in the following tables:

Fourth district levees, 1896-97.

LOWER TENSAS LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water previous to 1897.
					Feet.	*Feet.*	*Feet.*
1	Hard Times, Wilson..	632	R.	McGuire & O'Donnell.	6,600	4,000	3
	Evergreen:						
2	Section 1..........	637	R.	Batt O'Brien..........	1,660	1,500	5
3	Section 2..........	637	R.	.....do...............	1,200	2,500	5
4	Section 6..........	637	R.	.....do...............	1,200	2,000	5
5	Section 7..........	637	R.	.....do...............	1,200	2,000	5
	Bondurant:						
6	Section 1..........	642	R.	J. G. Boney...........	3,448	3,400	5
7	Section 2..........	642	R.	.....do...............	3,600	3,360	5
8	Winter Quarters, section 7.	640	R.	Charles O'Donnell....	2,752	2,200	5
9	Harpers, section 1....	651	R.	C. D. Leeper..........	6,359	15,700	5
10	Cottage Home, section 2.	650	R.	.....do...............	3,941	3,900	5
11	Rifle Point, section 4..	637	R.	Manning & Gibson...	4,447	4,500	5
12	Moro.................	709	R.	James R. Narlow.....	4,507	4,500	5

No.	Name of levee.	Section.			New or enlargement.	Average height.		Embankment.	Excavations.
		Crown.	Land slope.	River slope.		Above old levee.	Ground surface.		
		Feet.				*Feet.*	*Feet.*	*Cubic yds.*	*Cubic yds.*
1	Hard Times, Wilson..	8	3 to 1	3 to 1	Enlargement.	0.7	14.8	8,693.68	97
	Evergreen:								
2	Section 1..........	8	3 to 1	3 to 1	....do...	3.7	12.1	21,013.23	....
3	Section 2..........	8	3 to 1	3 to 1	....do...	3.7	12.1	15,571.82	20.63
4	Section 6..........	8	3 to 1	3 to 1	....do...	3.7	12.1	16,531.56	18.45
5	Section 7..........	8	3 to 1	3 to 1	....do...	3.7	12.1	15,439.59	39.75
	Bondurant:								
6	Section 1..........	8	3 to 1	3 to 1	....do...	3.2	12.4	31,881.28	....
7	Section 2..........	8	3 to 1	3 to 1	....do...	3	13.1	30,126.22	21.02
8	Winter Quarters, section 7.	8	3 to 1	3 to 1	....do...	3	13.3	28,288.86	485.75
9	Harpers, section 1....	8	3 to 1	3 to 1	....do...	2.4	12.7	42,937.32	616.28
10	Cottage Home, section 2.	8	3 to 1	3 to 1	....do...	2.6	13.2	31,005.88	10.67
11	Rifle point, section 4..	8	3 to 1	3 to 1	....do...	3.2	11.7	43,704.98	349.49
12	Moro.................	8	3 to 1	3 to 1	....do...	3.5	10.1	37,987.79	731.25

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Date of contract.	Work completed.	Distance from center of levee to river bank.			Nature of river bank.
							Least.	Greatest.	Average.	
		Cu. yds.	*Cents.*		1895.	1896.	*Feet.*	*Feet.*	*Feet.*	
1	Hard Times, Wilson.	8,790.68	11.70	$1,028.51	July 15	July 20	9,500	12,300	11,000	Caving.
	Evergreen:				1896.	1897.				
2	Section 1.......	21,013.23	9.43	1,981.55	Oct. 15	Mar. 29	3,000	2,900	3,500	Do.
3	Section 2.......	15,592.45	9.43	1,470.37	....do...	Mar. 16	4,000	9,000	6,000	Do.
4	Section 6.......	16,550.01	9.43	1,560.67	....do...	Jan. 5	2,800	8,700	6,000	Do.
5	Section 7.......	15,479.34	9.43	1,459.70	....do...	Jan. 18	2,000	2,800	2,400	Do.
	Bondurant:									
6	Section 1.......	31,881.28	9.25	2,949.02	....do...	Feb. 20	600	1,750	1,350	Do.
7	Section 2.......	30,147.24	9.25	2,788.62	....do...	Mar. 9	600	4,800	3,000	Do.
8	Winter quarters, section 7.	28,774.61	13.98	4,022.69	Sept. 5	Mar. 18	1,100	2,000	1,800	Stationary.
9	Harpers, section 1.	43,553.60	8.60	3,745.61	Dec. 14	....do...	2,000	9,000	7,000	Caving.
10	Cottage Home, section 2.	31,016.55	10.49	3,253.64	Sept. 5	1896. Dec. 22	2,000	4,500	3,500	Do.
11	Rifle Point, section 4.	44,054.47	9	3,964.90	Oct. 15	1897. Feb. 11	2,200	2,800	2,400	Making.
12	Moro.	38,719.04	8.50	3,291.12	Sept. 5	Mar. 3	320	750	520	Caving.

Fourth district levees, 1896-97—Continued.

ATCHAFALAYA LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Len of ax riv cover
					Feet.	*Fee*
1	Smithland	766	R.	E. P. White	981	
	Ennis to Smithland:					
2	Section 1	767	R.	McLaughlin Bros	5, 300	3,
3	Section 2	767	R.	do	5, 100	2,
4	Section 3	767	R.	do	4, 900	2,
5	Section 4	767	R.	do	4, 800	4,
	Raccourci to Longwood:					
6	Section 1	783	R.	E. P. White	2, 000	28,
7	Section 2	783	R.	do	2, 000	
8	Section 3	783	R.	do	2, 000	
9	Section 4	783	R.	do	2, 000	
10	Section 5	783	R.	do	2, 000	
11	Section 10	783	R.	do	2, 000	
12	Section 11	783	R.	do	2, 000	
13	Section 12	783	R.	do	2, 000	
14	Section 13	783	R.	do	2, 000	
15	Section 14	783	R.	do	1, 812	
	Poche to Morganza:					
16	Section 1	787	R.	do	3, 300	3,
17	Section 2	787	R.	do	3, 300	3,
18	Section 5	787	R.	do	3, 362	2,
19	Fanny Richie	794	R.	James R. Marlow	3, 112	2,
	Pointe Coupee:					
20	Section 1	797	R.	F. M. McLaughlin	1, 800	1,
21	Section 2	797	R.	do	1, 900	1,
22	Section 3	797	R.	James R. Marlow	2, 400	2,
23	Section 4	797	R.	do	2, 475	2,
	Alaska to Lakeland:					
24	Section 2	802	R.	C. H. Dameron	4, 200	4,
25	Section 3	802	R.	do	4, 200	4,
26	Section 4	802	R.	do	4, 700	4,
27	Section 5	802	R.	do	5, 300	5,
28	Stonewall	805	R.	McLaughling Bros	4, 127	4,
29	St. Claude	806	R.	do	3, 800	2,
30	Grand Bay	807	R.	Helgason Bros	4, 400	4,
	Highland to Wildwood:					
31	Section 1	812	R.	do	3, 300	3,
32	Section 2	812	R.	do	2, 900	2,
33	Section 8	812	R.	do	3, 200	3,
34	Section 9	812	R.	do	5, 615	5,
	Bellevale to Allendale:					
35	Section 1	825	R.	I. R. Bobbitt	2, 200	2,
36	Section 2	825	R.	do	2, 100	2,
37	Section 3	825	R.	do	2, 438	2,
	Viola to Belmont:					
38	Section 1	827	R.	do	2, 300	2,
39	Section 2	827	R.	do	2, 200	2,
40	Section 3	827	R.	do	1, 400	1,
41	Evan Hall	883	R.	J. M. Sullivan	936	
42	Smokebend	885	R.	do	4, 189	4,
43	Red River Landing	765	R.	E. P. White	7, 400	6,
44	Poche to Morganza, section 3	787	R.	do	3, 400	2,

Fourth district levees, 1896–97—Continued.

ATCHAFALAYA LEVEE DISTRICT—Continued.

No.	Name of levee.	Section.			New or enlargement.	Average height.		Embankment.	Excavations.
		Crown.	Land slope.	River slope.		Above old levee.	Ground surface.		
		Feet.				*Feet.*	*Feet.*	*Cubic yds.*	*Cubic yds.*
1	Smithland	8	3 to 1	3 to 1	Enlargement.	1.9	13	6,756.86	....
	Ennis to Smithland:								
2	Section 1	8	2½ to 1	3 to 1	....do...	4.2	11.5	26,061.67	258.87
3	Section 2	8	2½ to 1	3 to 1	....do...	4.2	11.5	25,200.10	333.91
4	Section 3	8	2½ to 1	3 to 1	....do...	3.9	11.2	25,301.36	24.18
5	Section 4	8	2½ to 1	3 to 1	....do...	1.9	12.4	26,376.28	421.76
	Raccourci to Longwood:								
6	Section 1	8	3 to 1	3 to 1	....do...	2.8	14.4	15,103.70	26.39
7	Section 2	8	3 to 1	3 to 1	....do...	2.8	14.4	13,383.47	12.71
8	Section 3	8	3 to 1	3 to 1	....do...	2.8	14.4	15,768.16	23.11
9	Section 4	8	3 to 1	3 to 1	....do...	2.8	14.4	18,211.86	33.33
10	Section 5	8	3 to 1	3 to 1	....do...	2.8	14.4	16,352.32	....
11	Section 10	8	3 to 1	3 to 1	....do...	2.8	14.4	9,443.88	....
12	Section 11	8	3 to 1	3 to 1	....do...	2.8	14.4	10,193.11	....
13	Section 12	8	3 to 1	3 to 1	....do...	2.8	14.4	8,719.30	....
14	Section 13	8	3 to 1	3 to 1	....do...	2.8	14.4	12,530.95	48
15	Section 14	8	3 to 1	3 to 1	....do...	2.8	14.4	11,262.71	72.81
	Poche to Morganza:								
16	Section 1	8	3 to 1	3 to 1	....do...	2.8	17.6	28,166.77	2,367.18
17	Section 2	8	3 to 1	3 to 1	....do...	2.8	17.6	29,519.66	67.15
17a	....	....	....	....	....	....	....	....	59.25
18	Section 5	8	3 to 1	3 to 1	Enlargement.	2.8	17.6	43,422.40	92.43
18a	....	....	....	....	....	....	....	....	3,568.58
19	Fanny Richie	8	3 to 1	3 to 1	Enlargement.	2.7	12.7	26,453.11	619.75
	Pointe Coupee:								
20	Section 1	8	3 to 1	3 to 1	....do...	2.1	15.8	19,390.20	....
21	Section 2	8	3 to 1	3 to 1	....do...	2.1	15.8	15,406.27	....
22	Section 3	8	3 to 1	3 to 1	....do...	2.1	15.8	13,415.20	1,470.87
23	Section 4	8	3 to 1	3 to 1	....do...	2.1	15.8	19,024.84	....
	Alaska to Lakeland:								
24	Section 2	8	2½ to 1	3 to 1	....do...	3.8	12.7	25,856.80	479.92
25	Section 3	8	2½ to 1	3 to 1	....do...	3.8	12.7	26,459.30	523.77
26	Section 4	8	2½ to 1	3 to 1	....do...	2.8	14.9	26,948.07	58.20
27	Section 5	8	2½ to 1	3 to 1	....do...	2.8	14.9	26,048.43	1,713.71
28	Stonewall	8	2½ to 1	3 to 1	....do...	2.6	11.2	13,755.85	....
29	St. Claude	8	2½ to 1	3 to 1	....do...	3.9	15.4	30,770.66	18.67
30	Grand Bay	8	3 to 1	3 to 1	....do...	2.3	15.1	28,189.13	....
	Highland to Wildwood:								
31	Section 1	8	2½ to 1	3 to 1	....do...	3.8	13.5	20,952.72	....
32	Section 2	8	2½ to 1	3 to 1	....do...	3.8	13.5	21,184.56	166.79
33	Section 8	8	3 to 1	3 to 1	....do...	1	17	23,974.90	751.37
34	Section 9	8	3 to 1	3 to 1	....do...	1	17	30,312.54	177.54
	Bellevale to Allendale:								
35	Section 1	8	2½ to 1	3 to 1	....do...	4.8	14.5	20,206.18	75.33
36	Section 2	8	2½ to 1	3 to 1	....do...	4.8	14.5	20,166.11	8.89
37	Section 3	8	2½ to 1	3 to 1	....do...	4.8	14.5	20,441.25	....
	Viola to Belmont:								
38	Section 1	8	2½ to 1	3 to 1	....do...	4.7	14.4	20,516.63	463.78
39	Section 2	8	2½ to 1	3 to 1	....do...	4.7	14.4	19,890.19	....
40	Section 3	8	2½ to 1	3 to 1	....do...	4.7	14.4	20,299	76.40
41	Evan Hall	8	2½ to 1	3 to 1	....do...	.6	9.5	2,210.20	2,828.50
42	Smokebend	8	2½ to 1	3 to 1	....do...	2	10.5	13,849.99	344.63
43	Red River Landing	8	3 to 1	3 to 1	....do...	1.6	16.2	59,200.96	2,469.97
44	Poche to Morganza, section 3.	8	3 to 1	3 to 1	....do...	2.8	17.6	36,881.60	58.37
44a	....	....	....	....	....	....	....	....	6,429.17

Fourth district levees, 1896-97—Continued.

ATCHAFALAYA LEVEE DISTRICT—Continued.

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Date of contract.	Work completed.	Distance from cen ter of levee t river bank.		
							Least.	Greatest.	Ave age
		Cu. yds.	*Cts.*		1896.	1866.	*Feet.*	*Feet.*	*Fee*
1	Smithland..........	6, 756. 86	12	$810. 82	May 4	Nov. 28	800	1, 180	9
	Ennis to Smithland:								
2	Section 1.......	26, 320, 54	8. 45	2, 224. 08	Mar. 21	Sept. 15	19, 480	11, 220	15, 3
3	Section 2.......	25, 534. 01	8. 45	2, 157. 63	....do ...	July 27	12, 220	8, 000	6, 0
4	Section 3.......	25, 325. 54	8. 45	2, 140. 00	....do ...	July 2	8, 000	1, 000	4, 0
5	Section 4.......	26, 798. 04	8. 45	2, 264. 44	....do ...	July 27	169	1, 500	1, 0
	Raccourci to Longwood:								
6	Section 1.......	15, 130. 09	8	1, 210. 41	May 4	Oct. 13	1, 300	35, 640	22, 0
7	Section 2.......	13, 396. 18	8	1, 071. 70	....do ...	Oct. 16			
8	Section 3.......	15, 791. 27	8	1, 263. 30	....do ...	Nov. 28			
9	Section 4.......	18, 245. 19	8	1, 459. 62	....do ...	1897. Jan. 15			
10	Section 5.......	16, 352. 32	8	1, 308. 19	....do ...	Feb. 16			
11	Section 10......	9, 443. 88	9	849. 95	....do ...	1896. Nov. 30			
12	Section 11......	10, 193. 11	9	1, 162. 38	....do ...	....do ...			
13	Section 12......	8, 719. 30	9	820. 47	....do ...	....do ...			
14	Section 13......	12, 578. 95	9	1, 132. 11	....do ...	Dec. 16			
15	Section 14......	11, 335. 52	9	1, 020. 09	....do ...	....do ...			
	Poche to Morganza:								
16	Section 1.......	30, 533. 95	16	4, 885. 43	....do ...	Nov. 28	1, 190	1, 420	1, 2
17	Section 2.......	29, 586. 81	12	3, 550. 42	....do ...	Oct. 13	770	1, 420	1, 0
17*a*	....	59. 25	9. 50	5. 63	....do ...	....do ...	......	......	....
18	Section 5.......	43, 514. 83	14	6, 092. 08	....do ...	Nov. 17	600	1, 100	8
18*a*	....	3, 568. 58	9. 50	339. 02	....do ...	....do ...	......	......	....
19	Fanny Richie......	27, 072. 86	8	2, 165. 83	May 27	Dec. 2	240	650	3
	Pointe Coupee:								
20	Section 1.......	19, 390. 20	13. 50	2, 617. 68	Nov. 12	1897. Mar. 13	1, 500	2, 370	2, 0
21	Section 2.......	15, 406. 27	11	1, 694. 69	....do ...	....do ...	1, 370	2, 370	1, 9
22	Section 3.......	14, 886. 07	9	1, 339. 75	May 27	1896. Sept. 22	520	1, 340	7
23	Section 4.......	19, 024. 80	8. 50	1, 617. 11	....do ...	Sept. 2	300	500	4
	Alaska to Lakeland:								
24	Section 2.......	26, 336. 72	7. 73	2, 035. 83	Mar. 21	Aug. 25	100	330	1
25	Section 3.......	26, 983. 07	7. 73	2, 085. 79	....do ...	....do ...	95	290	1
26	Section 4.......	27, 006. 27	7. 73	2, 087. 59	....do ...	July 27	125	350	2
27	Section 5.......	27, 762. 14	7. 73	2, 146. 01	....do ...	July 2	140	530	2
28	Stonewall	13, 755. 85	8. 45	1, 162. 37	....do ...	Dec. 22	2, 000	4, 000	3, 0
29	St. Claude..........	30, 789. 33	8. 45	2, 601. 70	....do ...	Sept. 19	970	2, 550	2, 0
30	Grand Bay.........	28, 189. 13	10. 50	2, 959. 86	July 6	Oct. 8	1, 470	1, 850	1, 6
	Highland to Wildwood:								
31	Section 1.......	20, 952. 72	10. 90	2, 283. 85	May 4	July 22	1, 040	1, 300	1, 1
32	Section 2.......	21, 351. 35	10. 90	2, 327. 30	....do ...	....do ...	1, 060	1, 300	1, 2
33	Section 8.......	24, 726. 27	19	4, 697. 99	....do ...	Nov. 2	3, 000	8, 000	5, 0
34	Section 9.......	30, 490. 08	11	3, 353. 91	....do ...	Oct. 8	3, 000	8, 000	5, 0
	Bellevale to Allendale:								
35	Section 1.......	20, 281. 51	9. 90	2, 007. 87	Mar. 21	Aug. 3	251	650	4
36	Section 2.......	20, 175	9. 90	1, 997. 33	....do ...	Sept. 16	620	650	6
37	Section 3.......	20, 441. 25	9. 90	2, 023. 68	....do ...	....do ...	171	708	5
	Viola to Belmont:								
38	Section 1.......	20, 980. 41	9. 90	2, 077. 06	....do ...	June 19	275	534	4
39	Section 2.......	19, 890. 19	9. 90	1, 969. 12	....do ...	....do ...	275	405	3
40	Section 3.......	20, 375 40	9. 90	2, 017. 16	....do ...	....do ...	260	350	3
41	Evan Hall..........	5, 038. 70	8. 50	428. 29	Mar. 27	July 3	200	210	2
42	Smokebend.........	14, 194. 62	8. 50	1, 205. 77	....do ...	....do ...	100	440	2
43	Red River Landing	61, 670. 93	24	14, 801. 02	May 4	Dec. 16	570	1, 550	1, 2
44	Poche to Morganza, section 3.	36, 939. 97	14	5, 171. 59	....do ...	1897. Mar. 20	680	1, 780	1, 2
44*a*	....	6, 429. 17	9. 50	610. 77	....do ...	....do ...	......	......	....

Fourth district levees, 1896–97—Continued.

LAFOURCHE LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water previous to 1897.
					Feet.	*Feet.*	*Feet.*
1	Peytavin	887	R.	Sullivan & Curtis	2,800	2,730	4
2	Sections 7, 8, 9, and 10	887	R.	Donovan & Daley	5,746	5,030	4
3	Sections 30, 31, 32, and 33	893	R.	.....do	5,173	5,173	4
4	Point Pleasant	893	R.	Sullivan & Curtis	5,228	5,000	4
5	Sections 36, 37, 38, and 39	895	R.	Donovan & Daley	4,277	4,277	4
6	La Pice	895	R.	Sullivan & Curtis	3,400	3,290	4
7	St. James Church	902	R.	John C. Hodge	5,900	5,900	4
8	St. James Estate	902	R.	.....do	4,242	4,170	4
9	Homes Place to Pikes Peak.	905	R.	Sullivan & Curtis	3,793	3,720	4
	Valcour Aime:						
10	Section 1	909	R.	.....do	4,100	4,000	4
11	Section 2	909	R.	.....do	4,100	3,990	4
	Star to Killona:						
12	Section 1	932	R.	.....do	3,900	3,850	4
13	Section 2	932	R.	.....do	3,900	3,820	4
14	Ashton	940	R.	Donovan & Daley	2,844	2,680	4
15	Lone Star	941	R.	.....do	3,227	3,160	4
	Fairfield:						
16	Section 1	955	R.	.....do	3,800	3,650	4
17	Section 2	955	R.	.....do	4,084	4,000	4
18	Columbia Garden, section 1.	959	R.	.....do	6,000	5,770	3
19	Davis to Lone Star, section 2.	944	R.	Victor Adema	3,655	2,870	3.5

No.	Name of levee.	Section.			New or enlargement.	Average height.		Embankment.	Excavations.
		Crown.	Land slope.	River slope.		Above old levee.	Ground surface.		
		Feet.				*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
1	Peytavin	8	2½ to 1	3 to 1	Enlargement.	2.1	13	11,565.08	9.35
2	Sections 7, 8, 9, and 10	8	3 to 1	3 to 1	....do	1.5	10.2	13,049.95	89.46
3	Sections 30, 31, 32, and 33	8	3 to 1	3 to 1	....do	.8	10.7	13,552.30	....
4	Point Pleasant	8	2½ to 1	3 to 1	....do	2	10.1	21,004.49	106.20
5	Sections 36, 37, 38, and 39	8	3 to 1	3 to 1	....do	1	10.7	13,353.06	410.80
6	La Pice	8	2½ to 1	3 to 1	....do	1.8	11.5	12,480.44	....
7	St. James Church	8	2½ to 1	3 to 1	....do	2	11.9	25,876.27	70.78
8	St. James Estate	8	2½ to 1	3 to 1	....do	2.1	10.9	17,590.15	10
9	Homes Place to Pikes Peak.	8	2½ to 1	3 to 1	....do	1.2	11	12,368.11	....
	Valcour Aime:								
10	Section 1	8	2½ to 1	3 to 1	....do	1.4	9.8	17,384.50	275.32
11	Section 2	8	2½ to 1	3 to 1	....do	1.4	9.8	15,830.88	286.47
	Star to Killona:								
12	Section 1	8	2½ to 1	3 to 1	....do	2	12.1	19,516.99	43.94
13	Section 2	8	2½ to 1	3 to 1	....do	2	12.1	19,968.87	170.89
14	Ashton	8	2½ to 1	3 to 1	....do	1.6	12.5	14,968.34	43.25
15	Lone Star	8	2½ to 1	3 to 1	....do	1.4	11.1	14,148.57	....
	Fairfield:								
16	Section 1	8	2½ to 1	3 to 1	....do	4.2	14.3	27,034.41	100
17	Section 2	8	2½ to 1	3 to 1	....do	4.2	14.3	25,738.84	938.16
18	Columbia Garden, section 1.	8	2½ to 1	3 to 1	....do	3.5	10.5	28,420.31	2,569.57
19	Davis to Lone Star, section 2.	8	2½ to 1	3 to 1	....do	2.5	15.8	22,975.79	700.21

Fourth district levees, 1896-97—Continued.

LAFOURCHE LEVEE DISTRICT—Continued.

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Date of contract.	Work completed.	Distance from center of levee to river bank.		
							Least.	Greatest.	Average.
		Cubic yds.	*Cents.*		1896.	1896.	*Ft.*	*Ft.*	*Ft.*
1	Peytavin	11,574.43	9.89	$1,144.71	July 17	Nov. 28	90	240	130
2	Sections 7, 8, 9, and 10.	13,139.41	9⅓	1,226.35	Dec. 11	1897. Mar. 18	100	650	370
3	Sections 30, 31, 32, and 33.	13,552.30	9⅓	1,264.88	....do	....do	170	270	200
4	Point Pleasant	21,110.69	9.89	2,087.82	July 17	Mar. 24	110	330	250
5	Sections 36, 37, 38, and 39.	13,763.86	9⅓	1,284.63	Dec. 11	Mar. 6	85	210	170
6	La Pice	12,480.44	9.89	1,229.17	July 17	Mar. 8	56	260	140
7	St. James Church	25,947.05	10	2,594.71	Jan. 20	1896. July 22	120	327	280
8	St. James Estate	17,600.15	10.90	1,918.42	....do	July 6	110	292	180
9	Homes Place to Pikes Peak.	12,363.11	9.89	1,222.71	July 17	Aug. 27	418	725	640
	Valcour Aime:								
10	Section 1	17,659.82	9.89	1,746.56	....do	1897. Jan. 21	580	760	630
11	Section 2	16,117.35	9.89	1,594.00	....do	1896. Nov. 17	340	700	550
	Star to Killona:								
12	Section 1	19,560.93	9.89	1,934.58	....do	Oct. 13	250	320	290
13	Section 2	20,139.76	9.89	1,991.82	....do	....do	160	300	290
14	Ashton	15,011.59	10.70	1,606.24	May 4	1897. Mar. 6	200	430	390
15	Lone Star	14,143.57	10.70	1,513.36	....do	1896. Oct. 8	155	370	230
	Fairfield:								
16	Section 1	27,134.41	10.70	2,903.38	....do	Dec. 26	182	320	200
17	Section 2	26,677	10.70	2,854.44	....do	....do ..	210	290	240
18	Columbia Garden, section 1.	30,989.88	10.70	3,315.91	....do	Sept. 16	170	500	320
19	Davis to Lone Star, section 2.	23,676	13	3,077.88	Feb. 13	Dec. 4	240	1,170	800

BARATARIA LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.
	Bruslard to Belle Chase:				*Feet.*	*Feet.*
1	1	981	R.	Thomas Egan, jr	10,323	10,240
2	2	983	R.	.....do	8,035	8,000
3	Concord	985	R.	.....do	5.478	5,420
4	Cedar Grove	989	R.	Joseph Hingle	5,056	5,056
5	Oakville	990	R.	.....do	4,344	4,344
6	Do	990	R.	Michael Cullen	2,660	2,660
7	Jesuits Bend	992	R.	Joseph Hingle	1,424	1,425
8	Dobard	992	R.	.....do	1.233	1,150
9	Toccoa	995	R.	.....do	3,198	3,180
10	Ironton	1,000	R.	.....do	2,905	2,905
11	Wood Park	1,002	R.	.....do	3,612	3,575
12	Wood Park to Deer Range.	1,003	R.	W. H. Harris	6,264	6,250
13	Deer Range	1,004	R.	Joseph Hingle	700	700
14	Point Celeste	1,007	R.	.....do	1,196	1,150
15	Point Celeste to Woodland.	1,008	R.	W. H. Harris	12,900	12,850
16	Woodland	1,010	R.	Joseph Hingle	1,356	1,356
17	Diamond	1,010	R.	Barbour & Ruple	2,231	2,230
18	Friends Store	1,014	R.	Joseph Hingle	1,937	1,925
19	Barthelemy	1,015	R.	.....do	1,957	1,960
20	Barthelemy to Riceland	1,015	R.	Victor Adema	4,300	4,180

Fourth district levees, 1896-97—Continued.

BARATARIA LEVEE DISTRICT—Continued.

No.	Name of levee.	Section.			New or enlargement.	Average height.		Embankment.	Excavations.
		Crown.	Land slope.	River slope.		Above old levee.	Ground surface.		
	Bruslard to Belle Chase:	*Feet.*				*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
1	1	8	2½ to 1	3 to 1	Enlargement.	0.6	9.5	15,898.11	101.45
2	2	8	2½ to 1	3 to 1	....do ...	.6	9.5	15,641.14	173.15
3	**Concord**	8	2½ to 1	3 to 1	....do ...	.7	8.8	10,187.02	....
4	**Cedar Grove**	8	2½ to 1	3 to 1	....do ...	.6	8	5,937.63	475.58
5	**Oakville**	8	2½ to 1	3 to 1	....do ...	.9	7.9	10,256.95	200.08
6	Do.	8	2½ to 1	3 to 1	....do ...	.9	7.9	6,835.36	4
7	**Jesuits Bend**	8	2½ to 1	3 to 1	....do ...	.8	8	2,820.90	6.44
8	**Dobard**	8	2½ to 1	3 to 1	New ...	....	9.1	13,539.23	156.31
9	**Toccoa**	8	2½ to 1	3 to 1	Enlargement.	.5	6.5	4,874.75	....
10	**Ironton**	8	2½ to 1	3 to 1	....do ...	.4	7.8	3,988.42	112.28
11	**Wood Park**	8	2½ to 1	3 to 1	....do ...	.7	8	11,880.62	539.70
12	**Wood Park to Deer Range.**	8	2½ to 1	3 to 1	....do ...	1.2	7.1	14,558.75	749.95
13	**Deer Range**	8	2½ to 1	3 to 1	....do ...	.5	7.2	936.92	46.66
14	**Point Celeste**	8	2½ to 1	3 to 1	....do ...	.4	6	936.71	96.10
15	**Point Celeste to Woodland.**	8	2½ to 1	3 to 1	....do ...	1	7.1	28,729.07	1,530.20
16	**Woodland**	8	2½ to 1	3 to 1	....do ...	.3	7.6	1,358.48	....
17	**Diamond**	8	2½ to 1	3 to 1	....do ...	2.8	7.8	7,458.71	383.75
18	**Friends Store**	8	2½ to 1	3 to 1	....do ...	.6	7.6	5,578.69	719.51
19	**Barthelemy**	8	2½ to 1	3 to 1	....do ...	.8	7.6	4,230.71	185.36
20	**Barthelemy to Riceland.**	8	2½ to 1	3 to 1	....do ...	1.2	8.2	8,749.78	345.49

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Date of contract.	Work completed.	Distance from center of levee to river bank.			Nature of river bank.
							Least.	Greatest.	Average.	
	Bruslard to Belle Chase:	*Cu. yds.*	*Cents.*		1896.	1896.	*Ft.*	*Ft.*	*Ft.*	
1	1	15,999.56	13.25	$2,119.94	Aug. 11	Oct. 31	80	450	250	Caving.
2	2	15,814.29	13.25	2,095.39	....do ...	Dec. 14	50	276	200	Washing and caving.
3	**Concord**	10,187.02	13	1,324.31	....do ...	1897. Jan. 27	140	250	200	Washing.
4	**Cedar Grove**	6,413.21	11	705.45	....do ...	1896. Oct. 21	110	200	140	Sloping.
5	**Oakville**	10,457.03	11	1,150.27	....do ...	Nov. 18	92	125	110	Do.
6	.....do	6,839.36	11.50	786.53	1897. Jan. 18	1897. Mar. 6	134	146	140	Do.
7	**Jesuits Bend**	2,827.34	11	311.01	1896. Aug. 11	1896. Dec. 16	110	180	140	Caving.
8	**Dobard**	13,695.54	11	1,506.51	....do ...	....do ...	105	190	175	Do.
9	**Toccoa**	4,874.75	11	536.22	....do ...	1897. Jan. 23	93	223	140	Sloping.
10	**Ironton**	4,100.70	11.30	463.38	....do ...	1896. Nov. 17	36	163	80	Do.
11	**Wood Park**	12,420.32	11.30	1,403.50	....do ...	Oct. 21	50	180	100	Washing.
12	**Wood Park to Deer Range.**	15,308.70	12.50	1,913.58	1895. Dec. 12	Dec. 26	40	160	100	Do.
13	**Deer Range**	983.58	11.30	111.14	Dec. 2	....do ...	135	135	135	Do.
14	**Point Celeste**	1,034.81	11.30	116.94	1896. Aug. 11	Nov. 17	38	130	60	Sloping.
15	**Point Celeste to Woodland.**	30,256.27	13.85	4,190.91	1895. Dec. 16	Oct. 2	77	218	150	Do.
16	**Woodland**	1,358.48	11.30	153.51	1896. Aug. 11	Oct. 21	110	140	125	Washing.
17	**Diamond**	7,842.46	13.45	1,054.81	1895. Dec. 16	Aug. 4	70	120	90	Sloping.
18	**Friend's Store**	6,298.20	11.30	711.69	1896. Aug. 11	Dec. 16	110	155	120	Do.
19	**Barthelemy**	4,416.07	11.30	499.02	....do ...	....do ...	65	140	100	Do.
20	**Barthelemy to Riceland**	9,095.27	11.98	1,089.61	Aug. 8	Dec. 11	40	250	140	Caving and washing.

Fourth district levees, 1896-97—Continued.

PONTCHARTRAIN LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.
					Feet.
1	Gartness	836	L.	George Y. Andrews	3,214
2	Laurel	839	L.	George Byrne	2,308
3	Laurel extension	839	L.	do	1,200
4	Conrad	840	L.	do	2,700
5	Conrad extension	840	L.	do	1,067
6	Woodstock extension.	848	L.	George Y. Andrews	235
7	Benkin	851	L.	George Byrne	3,361
8	Willow Glen	861	L.	Hayes Bros	8,336
9	St. Gabriel	862	L.	do	1,007
10	Virginia	863	L.	John Pollard	2,422
	Bowden:				
11	Section 1	880	L.	George Byrne	2,080
12	Section 2	880	L.	do	4,400
13	Dicharry	882	L.	Eltringham Construction Co.	5,897
14	Canti	882	L.	John C. Hodge	2,938
15	Canti extension	882	L.	do	1,858
16	Riverton	889	L.	Hearin & O'Connor	2,400
17	Burnside	891	L.	do	2,144
18	Union	893	L.	do	3,264
19	Lillie	900	L.	C. D. Leeper	1,995
20	Watson	918	L.	Donovan & Daley	3,746
21	Hope	919	L.	do	4,524
22	Reserve	921	L.	do	7,537
23	Cornland	923	L.	do	1,593
	Prospect:				
24	Upper	935	L.	Pat Deeley	4,051
25	Lower	937	L.	do	2,356
26	Morgan	947	L.	J. A. Andrews & Son	3,661
27	Edgewater	947	L.	Barbour & Ruple	1,389
28	Sauve	950	L.	Deeley & Burns	5,200
29	Boisblanc	952	L.	J. A. Andrews & Son	4,076
30	Soniat, lower	953	L.	John Cleary	1,057
31	La Freniere	953	L.	do	1,800

No.	Name of levee.	Section.			New or enlargement.	Average height.	
		Crown.	Land slope.	River slope.		Above old levee.	Ground surface.
		Feet.				*Feet.*	*Feet.*
1	Gartness	8	2½ to 1	3 to 1	Enlargement.	1.4	15.9
2	Laurel	8	2½ to 1	3 to 1	do	2.5	12.4
3	Laurel extension	8	2½ to 1	3 to 1	do	2.5	12.6
4	Conrad	8	2½ to 1	3 to 1	do	2.5	12.2
5	Conrad extension	8	2½ to 1	3 to 1	do	2.5	12.2
6	Woodstock extension.	8	2½ to 1	3 to 1	do	.8	12.2
7	Benkin	8	2½ to 1	3 to 1	do	1.9	11.8
8	Willow Glen	8	2½ to 1	3 to 1	do	1.4	10
9	St. Gabriel	8	2½ to 1	3 to 1	do	1.7	12.5
10	Virginia	8	2½ to 1	3 to 1	do	2	12.7
	Bowden:						
11	Section 1	8	2½ to 1	3 to 1	do	6.5	8.7
12	Section 2	8	2½ to 1	3 to 1	do	1.8	8.7
13	Dicharry	8	2½ to 1	3 to 1	do	1.7	13.3
14	Canti	8	2½ to 1	3 to 1	do	2.6	13.2
15	Canti extension	8	2½ to 1	3 to 1	do	2.6	13.2
16	Riverton	8	2½ to 1	3 to 1	do	3	11.3
17	Burnside	8	2½ to 1	3 to 1	do	1.5	7.6
18	Union	8	2½ to 1	3 to 1	do	2.3	10.3
19	Lillie	8	2½ to 1	3 to 1	do	2.5	10.8
20	Watson	8	2½ to 1	3 to 1	do	2.9	11.5
21	Hope	8	2½ to 1	3 to 1	do	2	11.1
22	Reserve	8	2½ to 1	3 to 1	do	1.4	9.5
23	Cornland	8	2½ to 1	3 to 1	do	1.3	9.9

Fourth district levees, 1896–97—Continued.

PONTCHARTRAIN LEVEE DISTRICT—Continued.

No.	Name of levee.	Section.			New or enlargement.	Average height.		Embankment.	Excavations.
		Crown.	Land slope.	River slope.		Above old levee.	Ground surface.		
	Prospect:	*Feet.*				*Feet.*	*Feet.*	*Cubic yds.*	*Cubic yds.*
24	Upper	8	2½ to 1	3 to 1	....do ...	1.9	9.5	14,846.95	329.27
25	Lower	8	2½ to 1	3 to 1	....do ...	1.8	8.7	7,042.88	143.41
26	Morgan	8	2½ to 1	3 to 1	....do ...	3.2	8.1	16,941.31	168.05
27	Edgewater	8	2½ to 1	3 to 1	....do ...	2.6	11.5	5,437.10	94.45
28	Sauve	8	2½ to 1	3 to 1	....do ...	1	11.2	35,721.40	1,026.68
29	Boisblane	8	2½ to 1	3 to 1	....do ...	2.5	10.5	14,370.34	693.57
30	Soniat, lower	8	2½ to 1	3 to 1	....do ...	1.6	8.9	6,224.97	19.78
31	La Freniere	8	2½ to 1	3 to 1	....do ...	2.2	9.8	11,571.92	353.65

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Date of contract.	Work completed.	Distance from center of levee to river bank.			Nature of river bank.
							Least.	Greatest.	Average.	
		Cu. yds.	*Cts.*		1896.	1896.	*Ft.*	*Ft.*	*Ft.*	
1	Gartness	28,180.15	10	$2,818.01	Feb. 29	Nov. 2	525	710	590	Caving.
2	Laurel	14,776.34	8.35	1,233.82	June 29	Sept. 16	105	250	160	Making.
3	Laurel extension	5,955.96	8.35	497.29	Sept. 30	Oct. 27	170	240	200	Caving slowly.
4	Conrad	17,179.38	8.35	1,431.41	June 29	Oct. 21	312	440	340	Making.
5	Conrad extension	5,785.82	8.35	483.12	Sept. 30	Oct. 27	220	370	320	Caving slowly.
6	Woodstock extension.	581.31	9	52.32	Feb. 29	July 16	400	415	405	Caving.
7	Benkin	16,963.83	10	1,696.39	Nov. 2	1897. Jan. 5	112	210	160	Washing and caving.
8	Willow Glen	26,455.08	9	2,380.95	May 19	1896. Aug. 11	210	475	375	Washing.
9	St. Gabriel	4,490.38	11.50	516.39	....do ...	....do ...	350	470	440	Caving.
10	Virginia	14,245.05	10.25	1,460.12	Nov. 13	1897. Feb. 15	254	560	480	Caving periodically.
	Bowden:									
11	Section 1	11,151.74	8	892.14	Mar. 28	1896. July 29	120	360	270	Caving.
12	Section 2	13,981.15	8	1,118.49	....do...	....do ...	100	300	130	Practically stationary.
13	Dicharry	51,423.33	10	5,142.33	Jan. 20	Sept. 21	380	1,050	680	Caving periodically.
14	Canti	19,236.62	10.40	2,000.61	July 14	Oct. 21	650	750	700	Caving.
15	Canti extension	10,015.43	10.40	1,041.60	....do ...	Oct. 13	590	720	680	Do.
16	Riverton	19,584.15	8.74	1,711.65	July 27	Nov. 17	190	300	250	Do.
17	Burnside	12,376.86	8.35	1,033.47	Aug. 29	Dec. 2	167	240	200	Washing.
18	Union	15,201.63	8.73	1,327.11	....do ...	1897. Feb. 15	160	260	180	Do.
19	Lillie	12,412.44	9.25	1,148.15	Aug. 3	1896. Dec. 21	160	390	300	Do.
20	Watson	18,895.62	10.20	1,927.35	May 6	Aug. 6	225	450	325	Caving.
21	Hope	9,447.51	10.20	963.65	....do ...	....do ...	205	840	630	Washing and making.
22	Reserve	28,730.96	8.50	2,442.13	....do ...	July 6	170	365	240	Upper end caving; lower end standing.
23	Cornland	4,199.98	10.20	428.40	....do ...	July 2	140	270	170	Caving.
	Prospect:									
24	Upper	15,176.22	8.50	1,289.98	May 27	Aug. 12	137	190	170	Washing bank.
25	Lower	7,186.29	10	718.63	....do ...	Sept. 15	170	325	275	Caving slowly.
26	Morgan	17,109.36	10	1,710.94	Nov. 12	1897. Jan. 19	140	300	225	Caving.
27	Edgewater	5,531.55	10.94	605.15	....do ...	Feb. 23	260	475	380	Do.
28	Sauve	36,748.08	9	3,307.33	Aug. 3	1896. Dec. 28	240	475	350	Do.
29	Boisblanc	15,063.91	10.50	1,581.71	Nov. 12	1897. Feb. 4	80	340	200	Caving and washing.
30	Soniat, lower	6,244.75	10	624.48	July 16	1896. Oct. 16	450	560	480	Stationary.
31	La Freniere	11,925.57	10	1,192.56	....do ...	Oct. 21	410	430	420	Washing.

Fourth district levees, 1896-97—Continued.

LAKE BORGNE LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.
					Feet.
1	Slaugter House extension.	968	L.	J. A. Andrews & Son....	2,394
2	Roy..................	970	L.	Robert McNamara & Co..	6,530
3	Belair................	996	L.	Charles G. Daunoy.......	4,573
	Fairview:				
4	No. 2............	996	L.	.....do..................	2,074
5	No. 3............	997	L.	.....do..................	4,200
6	Bonsejour	997	L.	.....do..................	480
7	Mousecour............	999	L.	Simon Leopold...........	1,397
8	St. Sophie to Harlem..	1,003	L.	.....do..................	1,300
9	Harlem	1,003	L.	.....do..................	3,890

No.	Name of levee.	Section.			New or enlargement.	Average height.	
		Crown.	Land slope.	River slope.		Above old levee.	Ground surface.
		Feet.				*Feet.*	*Feet.*
1	Slaughter House extension.	8	2½ to 1	3 to 1	Enlargement.	0.5	7.2
2	Roy	8	2½ to 1	3 to 1	....do ...	.4	7.4
3	Belair.............	8	2½ to 1	3 to 1	....do ...	1.0	7.5
	Fairview:						
4	No. 2..........	8	2½ to 1	3 to 1	....do ...	6.3	9.8
5	No. 3..........	8	2½ to 1	3 to 1	....do ...	.6	7.9
6	Bonsejour	8	2½ to 1	3 to 1	....do ...	.1	6.6
7	Monsecour	8	2½ to 1	3 to 1	....do ...	1.5	7.5
8	St. Sophie to Harlem.	8	2½ to 1	3 to 1	....do ...	.4	8
9	Harlem.............	8	2½ to 1	3 to 1	....do ...	.2	7

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Date of contract.	Work completed.	Distan from ce of leve river ba	
							Least.	Greatest.
		Cu. yds.	*Cents.*				*Ft.*	*Ft.*
1	Slaughter House extension.	4,253.56	14	$595.49	1895. Dec. 23	1896. Nov. 18	24	140
2	Roy	9,591.41	12.50	1,196.43	1897. Jan. 6	1897. Mar. 12	25	163
3	Blair	7,559.79	11.40	861.81	1896. Oct. 26	Mar. 8	121	300
	Fairview:							
4	No. 2...............	10,842.64	11.25	1,219.79	May 14	1896. Aug. 14	127	350
5	No. 3...............	5,655.49	11.40	644.72	Oct. 26	1897. Jan. 25	168	280
6	Bonsejour	675.34	13	87.80	....do ...	1896. Dec. 28	46	150
7	Monsecour	3,474.71	11	382.22	Mar. 20	Aug. 27	170	190
8	St. Sophie to Harlem..	2,151.79	11.75	252.84	1897. Jan. 18	1897. Mar. 9	145	231
9	Harlem	5,244.88	11.75	616.27	....do ...	....do ...	80	190

Summary of levees built from May 1, 1896, to May 1, 1897.

	Lower Tensas Levee district.	Atchafalaya Levee district.	Lafourche Levee district.	Barataria Levee district.	Pontchartrain Levee district.	Lake Borgne Levee district.	Total.
Earthwork ......cubic yards..	325, 572	969, 724	352, 642	180, 226	476, 256	49, 450	2, 353, 870
Embankment ....linear feet..	40, 914	136, 847	80, 169	81, 109	93, 816	26, 838	459, 693
Axis of river covered, linear feet	49, 760	132, 900	76, 986	80, 556	91, 230	26, 280	457, 709

In addition to the foregoing work of construction, numerous minor repairs to levees have been made, restoring embankments injured by wave wash and rain, repairing weak places, stopping leaks, cutting weeds, etc.

Statement of yardage of levee work constructed by the United States and others in the fourth district, Mississippi River.

	Levee districts.					
	Lower Tensas.	Atchafalaya.	Lafourche.	Barataria.	Pontchartrain.	Lake Borgne.
	Cubic yds.	*Cubic yds.*	*Cubic yds.*	*Cubic yds.*	*Cubic yds.*	*Cubic yds.*
Aggregate in levees on the Mississippi River, May 1, 1896	11, 643, 366	12, 682, 810	6, 171, 274	1, 902, 026	10, 613, 322	2, 344, 752
Added by the United States up to May 1, 1897	325, 572	969, 724	352, 642	180, 226	476, 256	49, 450
Added up to May 1, 1897, by State and levee boards	996, 127	254, 588	59, 126	37, 756	61, 938	91, 013
Sum	12, 965, 062	13, 907, 122	6, 583, 042	2, 120, 008	11, 151, 516	2, 485, 215
Lost by abandonment and crevasse, May 1, 1896, to May 1, 1897	*a* 38, 000	17, 000	....	22, 000	14, 000	....
Aggregate remaining May 1, 1897	12, 927, 065	13, 890, 122	6, 583, 042	2, 098, 008	11, 137, 516	2, 485, 215

a Of this, 23,000 cubic yards were lost by a crevasse.

In addition to the work done on the Mississippi River, the State of Louisiana and local levee boards have built levees on Red River, Atchafalaya River, Ouachita River, Bayou Lafourche, and Bayou De Glaize to the extent of 1,401,544 cubic yards, making a total of 2,902,092 cubic yards of levee work built by the State authorities in this district during the year.

Percentage of length of existing levee system built in whole or in part by the United States.

	Per cent.
Lower Tensas Levee district	63
Atchafalaya Levee district	68
Lafourche Levee district	61
Barataria Levee district	43
Pontchartrain Levee district	74
Lake Borgne Levee district	60
Percentage of total length of existing levee system Fourth district, Mississippi River, built in whole or in part by the United States	63

COST OF LEVEE BUILDING.

The progress made in reducing the cost of levee building this year is not apparent, though I am under the impression that the downward tendency of prices which has been so marked for the past four years has continued to some extent, as the work done this season has been more difficult than the average of recent years, the levees have been higher, and much of the work has been done on credit instead of for cash.

There has been no marked improvement in methods, the work being generally done with mules and wheel scrapers, as heretofore. One large contract has been made by the Atchafalaya levee board for the construction of levees on Bayou Lafourche, using the ordinary dipper dredge to dig the material from the bottom of the bayou, and a large pump to distribute it. While the conditions on Bayou L peculiar and exceptional, the success of this work may lead to a more g cation of mechanical means to levee building.

During the month of May, a second experiment was made in using the for levee construction. The levee at Nairn (1025 R) was raised and ex distance of 1,600 feet to a height of 7½ feet above the general level of 9,700 cubic yards of material were pumped from the bed of the river an in small terraces, as described in my report of last year. Many delaye account of the leaking of the terraces and the breaking of joints on pipe of the dredge, which were old and not in condition to stand a heav frequent interruptions made the experiment inconclusive and unsatisfac of cost. A further effort will be made to develop this method of const opportunity offers.

HIGH WATER.

On March 1 the gauge at Cairo having reached 41 feet, with very in the tributaries above, preparations were begun for protecting the high water. Owing to the failure of the general deficiency bill and th bill, there were no funds available except the amounts reserved fr allotments for levees made for this fiscal year, only one-half of which Under these conditions no very active part could be taken in protecti and the best use of the limited funds at hand appeared to be to m the entire plant of boats and barges belonging to the district. Fort and quarterboats were accordingly equipped with wheelbarrows, too materials for emergency use, and stationed at intervals of about 1 the levee line throughout the district. Tugboats were detailed to a for these barges at intervals of 60 miles to move them as promptly threatened points. All of the boats were in place by the time the ri to within 4 feet of high-water mark.

March 23 the sum of $9,000 was allotted to this district by the pr Commission, and $10,000 added by the Commission next day. On Marc mission allotted a further sum of $95,000, and on April 17 $20,000, fr gency appropriation of March 31. These funds made it possible to do strengthening the line. Accordingly, on March 31 I wrote to the pre levee boards below Red River inclosing lists of all the low places whic the grade of 3 feet, stating that if the levee boards would inform these levees they would raise 2 feet, I would endeavor to raise th The cooperation of the levee boards was secured in all instances, an was begun at once raising 71 miles of levee. A continuous 3-foot been obtained in the Atchafalaya and Pontchartrain districts, work commenced, with the cooperation of the levee boards, to secure a cont grade from Red River to Donaldsonville. This necessitated raising 80 miles of levee.

In the Tensas district most extraordinary activity was displayed board and the inhabitants, and in a surprisingly short time practica line from Ashley to Hard Times was raised from 1 to 3 feet, a distanc miles. This line has been held up to date, though in a very incomplet the face of extraordinary difficulties, greatly to the credit of the loc and of my assistant, Mr. W. J. Hardee, whose services in this emergen exemplary.

A crevasse occurred at Glasscock's (725 R. B. C.) about 3 p. m. April last reported was about 1,400 feet wide. All expectation of holding been abandoned at the time funds became available, as it was apparen the line broke above the water would rise 2 or 3 feet over the top which was very low and weak in section and situated so near the end that all opportunity to improve it was cut off by backwater from Bo of the line is in a swamp infested with beavers and muskrats, and it is tions of these animals that the break which occurred is attributed, the burst out suddenly near the base of the levee. Owing to the country under back water from Bougere and soon to be deeply submerged by cr from Biggs, no damage was done by this crevasse.

In the Lake Borgne district and the Barataria district, as far as S (1015 R. B. C.), the levee line had been raised to a grade of 3 feet at all where property owners had objected to the construction of the levee. were therefore, in proportion to the strain to be expected, much strong above. Operations have therefore been confined almost entirely to furn portation and materials in these districts, where a very active fight has on by the inhabitants throughout the high water.

The portion of the Barataria district below Socola's Canal has only organized as a levee district, and no work was done there by the United

ed. The levee line is generally very low and of extremely light sec-
asses are liable to occur at any moment; the local inhabitants are,
erienced in fighting high water, and have been most successful in
ne this year under conditions that seem almost impossible. Two
ave occurred near Little Texas (1022 R. B. C.), but both have been
ed. One was caused by the blowing out of a rice flume, and the
er flumes in this district and the Lake Borgne district is one of the
of this high-water campaign.
t flood has reached an unprecedented height from one end of the
o the other, and has so stood in some places for over two months,
the levees has on the whole been most satisfactory to date, there
eak in the system, and that at a point where no damage was caused
y, and in a levee which was not expected to hold.
ly weak link in the chain has been a small levee about a half a mile
of Baton Rouge, which is not within the jurisdiction of any organ-
t, but where a break would flood a large portion of the Pontchar-
Four small crevasses actually occurred in this levee, but they were
It finally became necessary to build a new line behind it for a dis-
500 feet. The expense of this construction was borne conjointly by
n Rouge, the Pontchartrain levee board, the parish of East Baton
llinois Central Railroad Company.
of the present high water has satisfied me that there is a necessity
nge in the method of applying the funds reserved for high-water

il, it is ordinarily from one of the five following causes:
t height, which permits the water to flow over the top of the levee,

aused generally by the operations of some burrowing animal, which
rmation of a hole through the levee, which rapidly enlarges as the
ugh it.
due primarily to some slight defect in the river face of the levee,
he water to filter too freely through the body of the levee, and to
ge of the land side, which permits the latter to become saturated
hat the earth will not stand with a slope of 1 on 3.
, which attacks the river face of new levees when the river is made
r passing steamers.
ue to the operations of malicious persons or people of deranged

otection work consists almost invariably in combating the above
lure, and any thorough scheme for such work should provide the
ventive or remedy for each of these difficulties near at hand and
l of some one skilled in their application. This is not now the case.
thod of doing high-water protection work is most complicated, expen-
nd uncertain, and it is a matter of surprise that so large a measure
achieved with such unsystematic efforts.
ndependent forces which assist in the work—the individual planter,
e parish, the levee district, the State, and the United States. There
d system for securing intelligent cooperation, and no settled and
tood policy as to what remedy should be applied when emergencies
men on the ground who happen to be interested generally begin the
sions often arise as to the method to be pursued, much to the disad-
ork.
f the levee is absolutely essential in extreme floods, as no earthern
ater flowing over the top of it for any length of time.
is capping till it has to be done in the face of a rising river, with
actually on the crown of the levee before the work is begun, is not
ive, but it is taking a risk that is not justifiable. When the cap-
ith sacks, as it often is, it costs not less than $2.50 per cubic yard,
l cost not more than 15 cents if done during the low-water season.
miles of the levee line of this district has been capped this year
water struggle.
mend, to meet this difficulty, that all the low places in the levee line
ance, so as to completely eliminate the first cause of failure.
barges and tugboats outlined above, while it has rendered invalu-
season, is both expensive and unreliable.
acticable to furnish more tugboats than one for every 60 miles, and
re apt to occur in several places far apart at the same time, there can
s to when the barge will arrive at the scene of the trouble; and, in
ninutes count almost as much as they do in fighting fire.
lingly recommend, with a view to meeting these difficulties, that a

portion of the high-water protection reserve be expended in advance in co
at intervals of about 5 miles along the levee line, cheap sheds or ware
mated to cost about $200 apiece, in which the necessary emergency out
barrows, tools, run plank, boards, pickets, and sacks may be kept in store,
can be promptly hauled over the top of the levee to the point where ne
can never be more than 2½ miles from the nearest warehouse. The lumb
cut and prepared in advance for the particular use to which it is to be a

At the beginning of the high-water season each of these warehous
adjoining 5 miles of levee, should be put in charge of a competent man,
to it that the back slope of the levee is properly drained, which will res
ing much of the trouble and danger now caused by sloughing. In the s
early information will be obtained of the existence of crawfish and m
which can be successfully treated at small expense if discovered early e

Throughout the whole of the high-water season this year extra work
and another has fallen to the lot of every employee of this office, and I t
in recording the invariable cheerfulness and good will with which ev
done his share, in hours and out of hours, by day or by night, as th
required.

HIGH WATER.

The following table shows the reading of the high-water mark at eac
ular gauges in this district for the past three years:

Gauges.	Bank full stage.	1895.		1896.		
		Reading.	Date.	Reading.	Date.	Reading.
	Feet.	*Feet.*		*Feet.*		*Feet.*
Vicksburg	44	31.7	Apr. 3	39	Apr. 21	52.50
St. Joseph	39.5	27.8	Apr. 3–4	35.20	Apr. 22	47.85
Natchez	47	31.5	Apr. 4–5	38.30	Apr. 22–23	49.80
Red River Landing	40	31.2	Apr. 4, 5, 6	37.40	do	50.20
Barbres	40	29.5	Apr. 5–6	35.80	Apr. 23–24	50.95
Bayou Sara	36	24.7	do	30.70	Apr. 22–23	43.80
Baton Rouge	29	23.6	Apr. 6	28.80	Apr. 22–25	40.65
Plaquemine	24.7	20	do	25.10	Apr. 22–24	36.25
Donaldsonville	24	18.6	do	23	Apr. 22–25	32.80
College Point	21	15.1	do	19.20	Apr. 22–24	27.95
Carrollton	9.2	10.1	Apr. 8	13.70	Apr. 24	19.05
New Orleans	9	11.1	Apr. 6	14.70	Apr. 23	19.50
Fort Jackson		4.4	Apr. 2	5.80	Apr. 26–29	7.20

LOWER TENSAS LEVEE DISTRICT.

The amount expended from June 30, 1896, to June 30, 1897, is $54,209.45
as follows:

Office expenses (main office)	
Other administrative expenses	
Construction of levees	
Repairs to levees	
Surveys	
Repairs to plant	
Care of plant	
New plant	
Total	

Money statement.

July 1, 1896, balance unexpended		
Amount allotted from appropriation, act of June 4, 1897		
June 30, 1897, amount expended during fiscal year		
July 1, 1897, balance unexpended		
July 1, 1897, outstanding liabilities	$250.0	
July 1, 1897, amount covered by uncompleted contracts	70,582.1	
July 1, 1897, balance available		

ATCHAFALAYA LEVEE DISTRICT.

xpended from June 30, 1896, to June 30, 1897, is $113.764.53, distributed

(main office)		$4,043.05
rative expenses		6,762.93
f levees		101,048.12
es		1,643.36
		146.56
t		58.78
		2.10
		59.63
		113,764.53

Money statement.

lance unexpended		$110,275.54
d from appropriation, act of June 4, 1897		168,750.00
		279,025.54
mount expended during fiscal year		113,764.53
lance unexpended		165,261.01
tstanding liabilities	$300.00	
nount covered by uncompleted contracts	16,656.28	
		16,956.28
lance available		148,304.73

LAFOURCHE LEVEE DISTRICT.

expended from June 30, 1896, to June 30, 1897, is $42,433.49, distrib-
:

(main office)	$2,130.79
rative expenses	2,236.62
f levees	36,364.07
es	1,190.97
	336.66
nt	77.79
	96.59
	42,433.49

Money statement.

lance unexpended	$48,778.66
d from appropriation, act of June 4, 1897	50,625.00
	99,403.66
mount expended during fiscal year	42,433.49
lance unexpended	56,970.17
nount covered by uncompleted contracts	5,860.04
lance available	51,110.13

BARATARIA LEVEE DISTRICT.

xpended from June 30, 1896, to June 30, 1897, is $32,056.80.

(main office)	$918.25
rative expenses	4,602.23
f levees	24,246.26
es	1,523.42
	459.78
t	113.13
	120.16
	72.97
	32,056.80

Money statement.

July 1, 1896, balance unexpended	
Amount allotted from appropriation, act of June 4, 1897	
June 30, 1897, amount expended during fiscal year	
July 1, 1897, balance unexpended	
July 1, 1897, outstanding liabilities	$80.0
July 1, 1897, amount covered by uncompleted contracts	1,829.2
July 1, 1897, balance available	

HOMOCHITTO LEVEE DISTRICT

Money statement.

July 1, 1896, balance unexpended
October 7, 1896, transferred to third district, improving Mississippi River

PONTCHARTRAIN LEVEE DISTRICT.

The amount expended from June 30, 1896, to June 30, 1897, is $54,622.96 as follows:

Office expenses (main office)
Other administrative expenses
Construction of levees
Repairs to levees
Surveys
Repairs to plant
Care of plant
New plant
Total

Money statement.

July 1, 1896, balance unexpended	
Amount allotted from appropriation, act of June 4, 1897	
June 30, 1897, amount expended during fiscal year	
July 1, 1897, balance unexpended	
July 1, 1897, outstanding liabilities	$310.0
July 1, 1897, amount covered by uncompleted contracts	7,635.5
July 1, 1897, balance available	

LAKE BORGNE LEVEE DISTRICT.

The amount expended from June 30, 1896, to June 30, 1897, is $8,757.24 as follows:

Office expenses (main office)
Other administrative expenses
Construction of levees
Repairs to levees
Surveys
Repairs to plant
Care of plant
New plant
Total

Money statement.

July 1, 1896, balance unexpended		$23,094.54
Amount allotted from appropriation, act of June 4, 1897		27,000.00
		50,094.54
June 30, 1897, amount expended during fiscal year		8,757.24
July 1, 1897, balance unexpended		41,337.30
July 1, 1897, outstanding liabilities	$75.00	
July 1, 1897, amount covered by uncompleted contracts	3,489.76	
		3,564.76
July 1, 1897, balance available		37,772.54

PRESERVATION OF WORKS.

The amount expended (on account of high water of 1897) to June 30, 1897, is $109,923.64, distributed as follows:

Office expenses (main office)	$3,509.29
Other administrative expenses	9,062.33
Labor	34,108.31
Material	30,063.29
Steamers	20,634.15
Fuel	4,937.28
Repairs to plant	3,722.70
Care of plant	821.01
New plant	3,065.28
Total	109,923.64

The amounts expended in the different levee districts are as follows:

Lower Tensas	$44,248.97
Atchafalaya	26,375.09
Lafourche	6,863.33
Barataria	3,190.22
Below Riceland	2,007.90
Pontchartrain	24,096.91
Lake Borgne	3,141.22
Total	109,923.64

Money statement.

March 23, 1897, amount allotted (transfer from third district)	$9,000.00
March 24, 1897, amount allotted (transfer from third district)	10,000.00
March 31, 1897, amount allotted (act of March 31, 1897)	95,000.00
April 17, 1897, amount allotted (act of March 31, 1897)	20,000.00
	134,000.00
June 30, 1897, amount expended during fiscal year	109,923.64
July 1, 1897, balance unexpended	24,076.36
July 1, 1897, outstanding liabilities	4,200.00
July 1, 1897, balance available	19,876.36

PLANT.

Money statement.

July 1, 1896, balance unexpended (new boat)	$10,000.00
Amount allotted from appropriation, act of June 4, 1897	20,000.00
July 1, 1897, balance unexpended	30,000.00

The following maps and appendixes accompany this report:

- Plate I. Natchez and Vidalia harbors.
- II. New Orleans Harbor.
- III. Fords Crossing.
- IV. Lower Tensas and Homochitto Levee districts.
- V. Atchafalaya, Lafourche, and Ponchartrain Levee distric
- VI. Barataria and Lake Borgne Levee districts.
- VII. Overflow map of Louisiana.
- Appendix A. Statement of value of plant.
- B. Commercial statistics.
- C. List of civilian engineers.
- D. Report of H. S. Douglas, assistant engineer, on Vidalia harbors.
- E. Report of H. S. Douglas, assistant engineer, on harbor.
- F. Report of H. S. Douglas, assistant engineer, on repa
- G. Report of A. F. Woolley, jr., assistant engineer, on and Red rivers.
- H. Report of A. F. Woolley jr., assistant engineer, Fords Crossing.
- I. Report of W. J. Hardee, assistant engineer, on New Orleans.
- J. Report of H. B. Watson, surveyor, on levees below
- K. Abstract of proposals.

Very respectfully, your obedient servant,

Geo. McC.
Captain of

Col. G. L. Gillespie,
Corps of Engineers, U. S. A.,
President, Mississippi River Commission.

Appendix 10 A.

Approximate value of plant belonging to the United States and used upon th of the Mississippi River, fourth district, May 1, 1897.

Class of property.	Value.	Class of property.
Steamer Osceola	$2,000	1 dry dock
Steam launch Ruby	3,000	28 skiffs
Tug General Comstock	6,000	Tools and appliances
Tug Tilda	4,000	Office furniture
Dredge The Ram	53,000	Surveying instruments
1 pile driver	1,600	Drawing instruments
5 quarterboats	14,700	Railway cars and track
35 barges	40,000	
1 warehouse barge	1,200	Total

Appendix 10 B.

Foreign commerce, port of New Orleans.

[The statistics relating to the foreign commerce of the port of New Orleans were k by Hon. T. S. Wilkinson, collector of customs.]

Vessels.	Entrances.			Clear
	1894–95.	1895–96.	1896–97.	1894–95.
Steam	1,176	812	1,236	1,092
Sail	91	69	72	72
Total	1,267	881	1,308	1,164

Total tonnage of above.

1894–'95
1895–'96
1896–'97

Exports and imports.

	1895.	1896.	1897.
Exports:			
Total value of exports of foreign merchandise to foreign countries	$319,200.00	$272,107.00	$298,319.00
Total value of exports of domestic merchandise to foreign countries	67,398,845.00	80,837,794.00	98,518,917.00
Total	67,718,045.00	81,109,901.00	98,817,236.00
Imports:			
Total value of imports from foreign countries—			
Free	10,983,592.00	9,405,403.00	9,357,466.00
Dutiable	3,193,362.00	4,978,500.00	5,409,332.00
Transit to Mexico			921,015.00
Transported to interior ports			1,184,048.00
Specie	434,200.00	469,161.00	615,571.00
Total	14,611,154.00	14,853,064.00	17,487,432.00
Total duties collected	1,088,812.91	1,602,183.82	2,039,146.73

APPENDIX 10 C.

List of civilian engineers employed on work of river and harbor improvements, fourth district, improving Mississippi River, from May 1, 1896, to May 1, 1897, in charge of Capt. Geo. McC. Derby, Corps of Engineers.

Name and residence.	Time employed.	Compensation per month.	Where employed.	Work on which employed.
	Months.			
H. S. Douglas, New Orleans, La.	12	$200	New Orleans, La., and Natchez, Miss.	Improving harbor at New Orleans, La., harbor at Natchez and Vidalia, Miss. and La., and levees, Lower Tensas district.
W. J. Hardee, New Orleans, La.	12	200	New Orleans and in the field.	Levees, Lower Tensas, Atchafalaya, Lafourche, and Pontchartrain districts.
William Garvin, New Orleans, La.	$8\frac{15}{31}$	125	New Orleans, La.	Improving harbor at New Orleans, La.
E. B. Geddes, Natchez, Miss.	12	150	Natchez, Miss., and in the field.	Levees, Lower Tensas district, and improving harbor at Natchez and Vidalia, Miss. and La., and improving harbor at New Orleans, La.
A. F. Woolley, jr., New Orleans, La.	12	150	New Orleans, La., Old River, and the field.	Improving Atchafalaya and Red rivers, Louisiana; surveys, gauges, and observations; levees, Lafourche district.
John Smyth, jr., New Orleans, La.	6	150	New Orleans, La.	Levees, Lake Borgne and Barataria Levee districts.

APPENDIX 10 D.

REPORT OF MR. H. S. DOUGLAS, ASSISTANT ENGINEER, IN LOCAL CHARGE OF IMPROVING HARBORS AT NATCHEZ AND VIDALIA, MISSISSIPPI AND LOUISIANA.

NEW ORLEANS, LA., *May 1, 1897.*

SIR: I have the honor to submit the following report on the work of improving the harbors at Natchez and Vidalia, Mississippi and Louisiana, for the period from May 1, 1896, to May 1, 1897:

At the date of last report no construction was in progress and the plant belonging to this work was laid up at the Government depot. The spur levee on Cowpen Neck was in fair condition, but the willow mattress revetment around the end had commenced to decay. There had been delivered on the bank under contract 1,655.69 tons of rock.

Work during the past year has been confined to raising and enlarging the spur

levee on Cowpen Neck, to replacing the brush revetment around the ou
rock, and to the maintenance of the levee during the extraordinary floo

The proposed grade of the levee system in the Lower Tensas Levee di
west bank of the river having been fixed at 5 feet above the flood of 18
necessary to raise that of the spur levee on Cowpen Neck to correspond.
survey was made and proposals for the work were opened December 2
proposed enlargement contained about 86,000 cubic yards and was to b
April 1, 1897.

Contractors commenced work on January 16, 1897. The total length o
enlarged was 19,225 feet, and on March 13, 4,675 linear feet of the levee ha
pleted and received. Considerable work had been done on the remainder
but none of it was completed.

On this date, March 13, the river was rising rapidly and it became evi
entire work would not be completed before the water would come agains
rains continued throughout the central and eastern valleys of the Missi
and an extraordinary flood was indicated. To avoid the possibility
being overtopped and destroyed, it was decided to raise the crown to th
if possible. A considerable portion of this topping was done by the c
contract price, but where the rising river cut off the supply of earth
of the levee it became necessary to continue this work by hired labor.
the topping was commenced there was about 12,000 feet of the levee t
raising from 0.5 to 2.5 feet. The capping was done in the following ma

Stakes 2 by 2 inches by 4 feet were driven about two feet deep into
the levee and 1 foot from the edge on the upstream side. The stakes w
feet apart. These stakes were then planked with lumber 1 inch thick,
up with earth. In some cases where the material was particularly ba
filled sacks was laid along the bottom of the planking to prevent the v
out underneath. In other places where the fill was greatest and earth n
to obtain, a double row of stakes and planking was put down and the sp
filled in with earth, obtained from the downstream crown and slope of
levee. The work was more difficult and costly than other similar wor
of the water being on both sides of the levee. Earth had to be obtain
hills at the eastern terminus of the levee and hauled or boated to the lo
it was needed. The launch *Ruby* and a small barge were used for transp
and material, and the small quarterboat *Beta* for quartering and su
necessary force of laborers, watchmen, etc. The sandy portion of the le
badly at numerous points and had to be heavily sacked to prevent a bre
the height of the flood, the current, after flowing around the end o
returned and impinged against the lower side about 500 feet from the
tinued against the embankment for about 1,000 feet. The levee in th
composed of pure sand and commenced to cut badly. It was necess
almost a continuous revetment of sacks along this portion.

The cost of all this work which was necessitated by the high-wate
was about $2,734.

Before the water came over the bank of the river, the rock revetmen
the willow mattress on the outer end of the levee had been built. Fou
of rock, containing 1,248.40 tons, were unloaded on the river bank at the
venient point to the end of the levee. Of this, 602.95 tons were haule
of the levee and distributed in convenient piles. The levee terminates i
curve 300 feet long and the side slopes and end are flattened to 5 to 1
revetment was laid by hand, and extends around the outer or upstream
curve, around the end and for 50 feet on the inner or downstream face o
This revetment covers the slope of the levee and extends from 5 to 10
to the berme. It is about 10 inches thick and its superficial area is
yards. The construction of the revetment was commenced March 1
completed March 20. The cost was:

602.95 tons of rock, at $1.64..
Hauling 602.95 tons of rock, at 25 cents...............................
Labor and superintendence..

Total..

During the year 5,211.21 tons of rock have been delivered and stored o
less the 602.95 tons used in the revetment. On two occasions the ca
bank has rendered it necessary to move a portion of the rock further
vent its loss.

So far as can be seen at the present stage of the river, caving of the b
Bend has continued at an undiminished rate, and this caving will proba
more active when the river falls within its banks.

Preparations are now being made to commence the work of bank p
this bend. Proposals have been asked for furnishing lumber and oth

and the plant is now being put in readiness for the work, which will be commenced as soon as the river falls sufficiently.

Very respectfully, your obedient servant,

H. S. DOUGLAS, *Assistant Engineer.*

Capt. GEO. McC. DERBY,
Corps of Engineers, U. S. A.

APPENDIX 10 E.

REPORT OF MR. H. S. DOUGLAS, ASSISTANT ENGINEER, IN LOCAL CHARGE OF IMPROVING HARBOR AT NEW ORLEANS, LA.

NEW ORLEANS, LA., *May 1, 1897.*

SIR: I have the honor to submit the following report on the improvement of the harbor at New Orleans, La., for the period from May 1, 1896, to May 1, 1897.

At the date of last report no construction was in progress, and the plant was laid up at the Government depot. The care, preservation, and repair of this plant is covered by a separate report.

As there have been no changes in the character of the mattress or cribs nor in the methods of ballasting and sinking these structures on the various submerged sloping spur dikes, a report must necessarily be confined to other features, principally the cost of the work of the season just closed. For comparative purposes considerable reference must be made to the work of previous years.

Unless stated otherwise, the cost given will be what may be termed the field cost, as it is believed that the figures given in all of the earlier reports were compiled only from such data as was known to the man in active charge of the works. Such expenses as office rent, clerical force, stationery, traveling expenses, etc., in main office were not known to him and were taken no account of. The cost of surveys, new plant, or repair and care of that on hand are not believed to have been so far charged to construction.

The work of improving the harbor of New Orleans may be said to have been commenced in the winter of 1883–84, when a mattress of the continuous woven type, 400 feet wide and 470 feet long, was sunk in the head of the Carrollton Bend. In 1884 practically the present project of submerged sloping spur dikes was adopted. There have been vast changes made in methods of construction, but the principle remains the same.

WORK OF 1885.

Spur dikes Nos. 2 and 3 were fully, and No. 5 about half, completed, in Gouldsboro Bend. The mattress was of the woven type, and the number of square feet placed was 210,000, at estimated cost of 7.6 cents per square foot. Four hundred and sixty-five thousand and thirty-six cubic feet of crib work was placed at an estimated cost of 3.6 cents per cubic foot. No details are given of the items going to make up the cost, and it is quite probable that the whole work was underestimated. The spurs were estimated to cost $12,500 each, but the total cost of the work for the year was $87,006.35. There was considerable material in the way of rock and iron rods left over. Three new barges had been purchased, and part or all of the cost of a steamboat came from the appropriation.

WORK OF 1886.

Owing to lack of funds no construction was undertaken. For the same reason the plant was not repaired, but $4,151.78 was required for its care and other expenses.

WORK OF 1887.

Spur dikes Nos. 1 and 6 were completed in the Gouldsboro Bend, and the cribs to complete Spur No. 5, left unfinished in 1885, made; 102,600 square feet of mattress and 377,874 cubic feet of cribs were built, but no published estimate is given of the cost per square or per cubic foot. It was thought that spur dikes could be built for $10,500 each. The cost of the work for the year was $40,299.47; of this a large percentage was required to repair the plant, which had greatly deteriorated, owing to lack of funds for its repair and preservation.

WORK OF 1888.

Spur dike No. 4 of the Gouldsboro series was completed; No. 5, commenced in 1885, finished, and No. 6, put down in 1887, repaired. The total square feet of mattress completed was 52,500, and the total cubic feet of crib work was 416,020. An

itemized statement of material used is given, and the cost of crib co
4.57 cents per cubic foot. It is stated that the mattress completed
9.11 cents per square foot. These figures are thought to be more
heretofore given. Three new barges were built and some repair
cost of the work for the year was $33,180.44.

WORK OF 1889.

Spur dike No. 1 of Greenville Bend series was nearly complet
thousand five hundred square feet of mattress was placed and 188
cribs. The estimated cost of crib work was $0.0402 per cubic foot,
mattress $0.0639 per square foot. The "framed mattress," since
standard in harbor work, was first used on the outer end of this spu
not admit of weaving a mattress of the required width. The fran
140 by 110 feet and cost $0.0956 per square foot. The cost of the
$77,557.31. Three new barges had been built, a quarter boat purc
out, a new boiler placed in the tugboat, a survey of the harbor e
$5,000 had been made, and $17,000 worth of rock, lumber, brush, a
was left on hand.

WORK OF 1890.

Spur No. 1 in the Greenville Bend that was partly finished the pre
completed. Spur No. 2 of the same series was finished, and Spurs
were built in the third district reach. Two hundred and nine thous
and fifty-four square feet of mattress and 974,287 cubic feet of crib
in the six spurs. The average cost of mattress per square foot wa
crib work per cubic foot $0.03622. From the details of material, 1
it is evident that this is the first estimate giving about the true
The woven mattress was finally abandoned this season and the
adopted. Spurs Nos. 1, 2, 3, and 4 of the third district reach serie
to high-water mark by a rock revetment. The field estimate
$75,647.54 and the actual amount expended during the year was $78
plant was purchased and but few repairs made.

WORK OF 1891.

Spurs Nos. 3, 4, and 5 of the Carrollton Bend series were built.
fifty-two thousand two hundred and fifty square feet of mattress
feet of cribs were placed in the three spurs. The average cost of ma
foot was $0.0987, and of cribs $0.0359 per cubic foot. These figures
be a very close approximation to the true cost of the work as th
unfavorable one. The framed mattress was used entirely. The
season's work was $41,542.59. The total amount expended duri
$78,688.08. Extensive repairs and alterations were made to the pla
$11,000. Material for construction valued at $8,903.15 was left on h

WORK OF 1892.

Spurs Nos. 1′, 2′, 3′, and 5′ of the third district series, and Nos.
Carrolton Bend series were built. Some of the third district spurs
back to the main levee by an earthen levee paved with rock. A sn
sunk below Spur No. 4 of the Carrollton Bend to prevent the spur
eddy action. In all 319,200 square feet of mattress and 890,664 cu
were placed. The average cost of mattress was $0.09218 per squ
cribs $0.03649 per cubic foot. The total field cost of the season's wo
The amount expended during the year was $72,951.21. There was
material left on hand, and $9,217.35 had been expended for care and
etc. The figures given for this season's work are evidently quit
believe can be relied on.

WORK OF 1893.

The work of this season was confined to mattress construction fo
revetment of a portion of the Carrollton Bend. No cribs were bu
tunity was given of obtaining the absolute cost of mattress wo
was placed 652,020 square feet of mattress at a cost of $58,159 0
square foot. The total amount expended during the year was $84,
barges, at a total cost of $13,874, were built under contract, and cur
made to plant.

WORK OF 1894.

Nothing was done, even in the way of necessary repairs to plant
exhaustion of funds.

WORK OF 1895.

The operations of the season were to lay a continuous mattress revetment from Spur 1′ to Spur 2′ of the third district series, and the laying of the foundation mattresses for Spurs 2½′, 3½′, and 4½′ of the same series, together with some small mattresses immediately below Spurs 2′, 3′, 3½′, 4′, and 4½′. The work of this season was again confined entirely to mattress construction, 744,000 square feet having been placed at a cost of $61,945.62, or $0.08326 per square foot. The total amount expended during the year was $93,873.09. The value of material left over was $3,503.62, and $14,977.28 was expended in repairs to plant.

WORK OF 1896.

Owing to limited funds on hand no construction was undertaken. Care and current repairs to plant cost $4,688.85.

WORK OF 1897.

In a report on bank protection, dated June 6, 1896, which I was directed to make, the following occurs:

"Going somewhat into details it may be stated that one of the principal objections to both the fascine and woven mattress is that they must be built on the spot where they are to be sunk and of the full dimensions required.

* * * * * * *

"With the framed mattress it can be built at any point above the proposed locality where it is to be sunk that willow or other suitable brush can be obtained. The brush will require to be handled but once, directly from the bank into the mattress. The length of but one barge extending out into the river is required, and that can be placed in a sheltered locality where the possibility of accident is reduced to a minimum. I can conceive of a locality near the foot of a sand bar overgrown with willows, where ways on the bank would answer and no floating plant of any kind be required. Construction can be commenced if desired during high water, and all of the mattresses built so that advantage can be taken of a favorable stage of the river to sink. The longer time after the mats are built before they are sunk the less rock it will take to sink them. By using a pump with hose and nozzle to wash out collected sediment the mattress can be parked and kept afloat for an indefinite length of time.

* * * * * * *

"In case of spur dikes nearly all the advantages of the framed mattress are possessed by the cribs. They can be built at any distance from the proposed work, and can be parked and kept afloat for an indefinite length of time."

At the time the foregoing was written I had, of course, no idea that this plan was to be carried out at all, much less under my personal direction, but on October 1, 1896, I again assumed local charge of the improvement of the harbor of New Orleans after an absence of six years (from November 7, 1890).

I found that a detailed project for the work had been prepared by Lieut. Charles S. Riché, Corps of Engineers, the two main features of which were the construction of mattresses and cribs at the locality where the willows were cut, in accordance with my suggestion, and the use of a double set of plant in sinking, so as to cover two spurs at a time. It was found that this last feature or detail was a necessary accompaniment of the first if the force was to be utilized to the best advantage.

On October 1 I assumed charge of the work. On October 9 a force of 104 men had been organized and, with the necessary plant, left New Orleans for Profits Island, arriving on the 11th. On October 15 two sets of mattress and crib ways had been built and the cutting of willows and construction of cribs commenced. On November 16 the first tow of cribs started for New Orleans. By November 29 the construction of mattresses and cribs had been completed and the force transferred to New Orleans. On January 9 the work was completed, 192,000 square feet of mattress and 606,720 cubic feet of cribs having been successfully placed in eight spurs. As the force was organized and left New Orleans October 9 for Profits Island the total time for the work was exactly ninety-three days. The cost of mattress was $0.0617 per square foot, and of cribs, $0.0295 per cubic foot. The total field cost of the season's work was $29,775.73. The total amount expended to February 1 was $51,074.60.

As to details:

The project contemplated the completion of Spurs 2½′, 3½′, 4′, and 4½′ in the third district reach, the foundation mattresses of which had been placed in 1895, and the construction of four new spurs, A, B, C, and D, in the intervals between Spurs 5′, 1, 2, 3, and 4 of the same reach.

It having been determined to try the plan of building the mats and cribs at the

locality where the willows were cut, a force of about 100 men
placed on the quarter boat *New Orleans*, which had been equippe
sist about 200 men. The necessary tools and appliances were c
ber 9 the quarter boat, with one barge of lumber and one of coal,
General Comstock for Profits Island, arriving on Sunday, Octobe
menced cutting willows and constructing two sets of ways c
construction was commenced October 15 and completed Novem
feet having been built. Mattress construction was commenced
pleted November 27, 192,000 square feet having been built. The
for construction was forty working days, and the cost of labor an
moving from and to New Orleans, was $14,659.37.

The towing of the completed mattresses and cribs to New Orl
November 16 and the last tow arrived December 12. The time
(*Comstock*) with double crew was twenty-three days, and the c

After the completion of construction at Profits Island the qua
was towed to the third district reach, New Orleans Harbor, t
and the sinking of the cribs and the mattresses on the eight sp
first crib was sunk on Spur 2½′ on December 4, and the last spu
uary 9, the actual number of working days being twenty-six.
mencing work on Spur 2½′ it became evident that two sets of
in order to avoid loss of time and idle labor. The second set
position for Spur A, and by transferring the greater portion o
set of plant to the other a large force was operated and idle la

At Profits Island two sets of ways were constructed for bui
cribs. These ways cost as follows:

17,000 feet, B. M. lumber, at $8.65
1,900 pounds wire nails, at $0.0345
Subsistence, including service
Labor, superintendence, etc

Total

In constructing mats and cribs 5,553 cords of willow brush
the detailed cost of which was:

Cutting, hauling, etc
Subsistence, including service
96.1 acres of land at $1 per acre

Total
Towing from Profits Island to New Orleans

Total

Number of cords of willows and poles used

Cost per cord delivered at ways
Cost per cord for towing to New Orleans

Total cost delivered at New Orleans

The cost of subsistence for the season work was:

Provisions, including ice, freight, etc
Service

Total

Number of men subsisted
Cost of raw ration
Cost served
Cost served per days labor secured

The total cost of constructing the mattresses and cribs inclu
ing up to Profits Island and returning to New Orleans, the bu
ways, etc., was $14,659.37, divided as follows:

Cribs.

108,000 feet B. M. lumber
8,000 pounds wire nails
680 pounds No. 10 wire
Miscellaneous, oil, fuel, United States ram, etc
Subsistence, including service
Labor, superintendence, etc

Total

Mattresses.

90,000 feet B. M. lumber	$778.50
9,600 pounds steel wire nails	331.20
800 pounds No. 10 wire	10.40
Miscellaneous, oils, fuel, United States ram, etc	141.34
Subsistence, including service	935.66
Labor, superintendence, etc	3,675.23
Total	5,868.33
Cost per cubic foot for cribs at Profits Island	0.0145
Cost per square foot of mattresses at Profits Island	.0305

The wiring of the mattresses was not quite completed at Profits Island, but this would add but little to the cost. Willow brush is included in labor and subsistence.

The total cost of towing the cribs and mattresses from Profits Island to New Orleans was $1.147.34, divided as follows:

Cribs.

Fuel oils, etc	$245.17
Provisions	45.00
Labor, crew of tug, etc	283.50
Total	573.67

Mattresses.

Fuel, oils, etc	$245.17
Provisions	45.00
Labor, crew of tug, etc	283.50
Total	573.67
Cost per cubic foot of cribs for towing	0.0009
Cost per square foot of mattresses for towing	.0030

Four trips of the tug were made, two with cribs in tow and two with mattresses. The time occupied on each trip and, consequently, the expenses were practically the same as given above.

From the foregoing the following has been compiled:

Cost of cribs per cubic foot delivered in New Orleans	$0.0154
Cost of mattresses per square foot delivered in New Orleans	.0335

The sinking of mattresses and cribs was commenced December 3, and the last crib was placed January 9. The actual working time being twenty-six days and the cost of labor and material $13,969.02.

The cost per square foot of mattress in place was $0.0617 divided as follows:

Construction at Profits Island	$0.0305
Towing, Profits Island to New Orleans	.0030
Ballasting and sinking in position	.0282
Total	.0617

The cost per cubic foot of cribs in place was $0.0295 divided as follows:

Construction at Profits Island	$0.0145
Towing, Profits Island to New Orleans	.0009
Ballasting and sinking in place	.0141
Total	.0295

ROCK.

Rock for ballasting mattresses and cribs was obtained, delivered on United States barges in New Orleans Harbor, as follows:

211.70 tons ship's ballast, purchased in open market, at $1 per ton	$211.70
700.62 tons old paving stones, purchased under contract, for $1.71 per ton	1,198.06
4,026.34 tons limestone rock from Alabama, purchased under contract, at $2.21 per ton	8,898.21
Total (4,938.66 tons)	10,307.97

Of this amount 3,223 tons, valued at $6,922.21, were used, and the balance, 1,715.66, valued at $3,385.76, was unloaded on the bank at the Government depot The cost

of unloading was $236.32, which would make the cost of this rock on
per ton.

The material now on hand for spur-dike construction and its value

3,710 tons of rock, at say $2.25..
195,000 feet B. M. lumber, at $8.65.....................................
12,000 pounds wire nails, at $0.0345....................................
6,600 pounds No. 10 wire, at $0.013.....................................

Total...

As a matter of interest, and because the data is on hand, I give de
ferent spurs as follows:

SPUR 2½'.

The work on this spur was confined to cribs, the foundation mattr
placed in 1895. The plant was placed in position December 3 and t
sunk December 7. The dimensions of the cribs were:

Crib No. 1, 40 by 28 by 6; crib No. 2, 32 by 70 by 6; crib No. 3,
crib No. 4, 16 by 294 by 6.

Cubic feet of cribs in spur..
Cords of willows and poles used..
Tons of rock used..
Pounds rock used per cubic foot to sink..................................

SPUR 3½'.

As on the previous spur the foundation mattress had been sunk in 1
was swung into position December 8 and the last crib was sunk o
The dimensions of the cribs were:

Crib No. 1, 40 by 136 by 6; crib No. 2, 32 by 207 by 6; crib No. 3,
crib No. 4, 16 by 337 by 6.

Cubic feet of cribs in spur..
Cords of willows and poles used..
Tons of rock used..
Pounds of rock used per cubic foot to sink...............................

SPUR 4'.

Foundation mattress was sunk in 1895. The plant was swung into
ber 14 and the last crib was sunk December 17. The dimensions of

Crib No. 1, 40 by 46 by 6; crib No. 2, 32 by 117 by 6; crib No. 3,
crib No. 4, 16 by 315 by 6.

Cubic feet of cribs in spur..
Cords of willow brush and poles used.....................................
Tons of rock used..
Pounds of rock used per cubic foot to sink...............................

SPUR 4½'.

Foundation mattress sunk in 1895. The plant was swung in positi
and the last crib was sunk December 21. The dimensions of the cri

Crib No. 1, 32 by 50 by 6; crib No. 2, 24 by 143 by 6; crib No. 3, 1

Cubic feet of cribs in spur..
Cords of willows and poles used..
Tons of rock used..
Pounds of rock used per cubic foot to sink...............................

SPUR A.

This and the following spurs, B, C, and D, were entirely new sp
swung into position December 15. The foundation mattress was su
and the last crib was placed December 24. The dimensions of the m
by 400 by 2½.

Square feet in mattress..
Cords of willows and poles used..
Tons of rock used..
Pounds of rock per square foot to sink...................................

The dimensions of the cribs were:
Crib No. 1, 24 by 226 by 6; crib No. 2, 16 by 300 by 6.

Cubic feet of cribs in spur	61, 344
Cords of willows and poles	353
Tons of rock used	185
Pounds of rock per cubic foot to sink	6. 03

SPUR B.

The plant was swung into position December 24. The mattress was sunk December 29 and the last crib was placed December 31. The dimensions of the mattress were 120 by 400 by 2½.

Square feet in mattress	48, 000
Tons of rock used	500
Cords of willows and poles	500
Pounds of rock per square foot to sink	16. 08

The dimensions of the cribs were:
Crib No. 1, 32 by 34 by 6; crib No. 2, 24 by 120 by 6; crib No. 3, 16 by 263 by 6.

Cubic feet of cribs in spur	49, 056
Cords of willows and poles	292
Tons of rock used	186
Pounds of rock per cubic foot to sink	7. 58

SPUR C.

The plant was swung into position December 30. The mattress was sunk January 2 and the last crib was placed January 6. The dimensions of the mattress were 120 by 400 by 2½.

Square feet in mattress	48, 000
Cords of willows and poles	500
Pounds of rock per square foot to sink	16. 58

The dimensions of the cribs were:
Crib No. 1, 32 by 55 by 6; crib No. 2, 24 by 212 by 6; crib No. 3, 16 by 242 by 6.

Cubic feet of cribs in spur	64, 320
Cords of willows and poles used	381
Tons of rocks used	175
Pounds of rock per cubic foot to sink	5. 44

SPUR D.

The plant was swung into position January 4. The mattress was sunk January 7 and the last crib was placed January 9. The dimensions of the mattress were 120 by 400 by 6.

Square feet in mattress	48, 000
Cords of willows and piles used	500
Tons of rock used	255
Pounds of rock per square foot to sink	10. 62

The dimensions of the cribs were:
Crib No. 1, 24 by 208 by 6; crib No. 2, 16 by 265 by 6.

Cubic feet of cribs in spur	55, 392
Cords of willows and poles used	322
Tons of rock used	229
Pounds of rock per cubic foot to sink	8. 25

The total cost of labor and material in sinking the mattresses and cribs was $13,969.02, and the total cost of the entire season's work was $29,775.73, divided as follows:

3,223 tons of rock, at $2.1477	$6, 922. 21
5,553 cords of willows and poles, at $0.6568	3, 647. 34
4,062 barrels of coal, at $0.225	913. 95
215,000 feet B. M. lumber, at $8.65	1, 859. 75
18,600 pounds steel wire nails, at $0.0345	641. 70
4,800 pounds No. 10 wire, at $0.013	62. 40
1,000 linear feet five-sixteenths inch wire strand, at $0.01	10. 00
Cylinder, lard, and headlight oil	125. 92
United States ram, 7 days, at $20	140. 00

Provisions, including ice ....
Pay rolls, services..........

Total ....

The total amount expended for improving the harbor of New Orlea
1896, to February 1, 1897, is $57,561.76, a difference between the fiel
the actual expenditures of $27,786.03.
The difference is made up as follows:

Repairs to plant..........
Care of plant..........
New plant ....
Surveys..........
Main office and other administrative expenses ....
Material for construction purchased but still on hand, say..........

Total..........

It may be noticed that the value of the material on hand does not c
given elsewhere ($10,524.05). The reason of this is that some of th
on hand was purchased and paid for last year. The other amounts
the office records.
Incidentally to construction, surveys were made in the third dist
in the Carrollton Bend. A careful traverse line on true meridia
angle points marked with iron castings. The center line of the seve
marked with two iron posts and tied into the traverse line. In addit
permanent points were carefully referenced to intersections of stre
back from the river, so that they can be replaced, even if the entire le
or moved. In the third district reach several lines of soundings w
each spur to determine its condition and sections of the bank we
2,000 feet below the last spur to obtain data for comparison should i
to extend the spur dike sytem in this reach.
It appears to be difficult if not impossible to separate the absolu
season's work from another. The wire rope, manila rope, tools, co
veying outfit, etc., purchased this year, may last for several succe
work, and to charge them all to the work of one year would not only
would be misleading.
It is difficult to prorate such things. The repairs of tugs, quarter
etc., have amounted to $12,086.91 so far this year. Just what portion
be charged to this season's work would be hard to determine. Th
plant necessitating these repairs was not caused by this year's service
past years. Again, the plant has been used considerably on works o
Orleans Harbor, and it would be manifestly wrong to charge the we
other service against the harbor work. It occurs to me that a char
per cent on the value of the plant used would give a close approx
amount that should be charged to any particular season's work. T
would have to be obtained from the cost of caring for and repairing
period of years.
As the object of the work is to prevent caving of the river bank
running foot of bank protected would be the proper unit. Here, agai
of separating the cost of one season's work from another is encounte
work of 1896–97. How many linear feet of bank have been protected
and how much by that of previous years? By what rule other tha
one could you state that Spur A protected half the interval betwe
Spur 1? If it does, suppose Spurs 5′, 1, 2, 3, and 4 had not been buil
A, B, C, and D have been located so as to protect a length of bank
they do now, or more, or less?
After reflection and consideration of the various difficulties, some o
endeavored to outline in the preceding paragraph, I have concluded
following:
Take the whole length of bank protected in New Orleans Harbor,
the upper and lower spurs of each locality protect above and below t
equal to half the interval between them and the adjacent spur; ta
thus obtained in linear feet; obtain the total cost of improvement o
Harbor since 1883–84; deduct from the total cost the value of the plan
on hand, this value being assumed at what it would cost to replace
particular boat, barge, etc.; divide the remainder by the length of
tected in feet, and the quotient will be the true cost per linear foot.
My method of arriving at the cost of the plant is as follows: If ba
destroyed it would be necessary to replace it with another barge costi

which, I take it, represents the value of the existing barge to the work. On this basis I have compiled the following:

Tug *Tilda*	$5,000.00
Quarter boat *New Orleans*	8,000.00
Outfit on quarter boat	2,000.00
Warehouse barge with outfit	4,000.00
Mooring barge No. 2	4,000.00
Dock	4,000.00
Barges 1, 3, 4, 5, 6, 7, 8, 15, 16, 17, and 18, at $3,000 each	33,000.00
Wire rope, manila rope, tools, and other appliances	5,000.00
Stock, lumber, nails, etc	10,534.05
Total	75,534.05

By examination of the maps I find the length of bank protected to be:

	Linear feet.
In the Carrollton bend	4,470
In the Greenville bend	1,850
In the Gouldsboro bend	4,325
In the third district reach	8,230
Total linear feet	18,875

According to the published reports and information on file the total amount expended to February 1, 1897, on New Orleans Harbor since 1883-84 is $775,267. Subtract $75,534, the value of plant and material on hand, leaving $699,733. Divide by 18,875, the number of linear feet of bank protected, gives $37.70 as the cost per running foot.

This is, in my opinion, a very favorable showing, and I think it quite probable that if works at other localities were analyzed on the same basis the result would be very surprising. It should be borne in mind that the average width of mattress placed and the average depth of water is considerably greater than elsewhere on the Mississippi River where work having a similar object in view has been undertaken.

As calculated in the field the mattress work of the present season cost $0.0617 per square foot, and crib work $0.0295 per cubic foot. This result has been disappointing to me. In my report of June 6, 1896, I showed that brush and poles made from 21 to 30 per cent of the total cost of spur dikes, and stone from 23 to 28 per cent. In suggesting the plan of constructing the mattresses and cribs at the locality where the willows were obtained a two-fold economy was expected to result—in the cost of willow brush, by dispensing with one handling and the cost of towing empty barges one way; and in stone, because the mats and cribs would be in the water for such a length of time that their flotation would be overcome to a great extent and less stone would be required to sink them. Let us see whether or not these results have been attained by reference to the reports of past years.

Comparative cost of willow brush and poles.

[Delivered in New Orleans Harbor, per cord.]

1884	$1.75	1891	$2.07
1885	1.84	1892	2.00
1887	2.22	1893	2.15
1888	1.70	1895	1.36
1889	1.81	1897	0.86
1890	1.77		

Comparative table showing pounds of rock used to sink mattresses and cribs.

Year.	Pounds per cubic foot of cribs.	Pounds per square foot of mats.	Year.	Pounds per cubic foot of cribs.	Pounds per square foot of mats.
1890	6,818	14,080	1893		14,560
1891	5,880	12,670	1895		18,894
1892	6,687	15,353	1897	648	13,086

From these tables it is evident that the cost of willow brush has been reduced about one-half. With the stone the saving has been inconsiderable. The explanation of this is very simple. In 1891 when the minimum quantity of rock was used

the reports state that owing to the high stage of the river the
up so fast that they had to be washed out with a jet from a st
their sinking before the plant could be put in position. Durin
the river remained at a very low stage and was almost free fr
the mats and cribs after being afloat for nearly two months flo
first launched.

Prior to 1890 the data obtainable as to the cost of mattres
believed to be very reliable. I have therefore compiled the foll
parative cost of mats and cribs, commencing with 1890:

Year.	Mattress, per square foot.	Cribs, per cubic foot.
1890	$0.07126	$0.03622
1891	.09870	.03590
1892	.09218	.03649
1893	.08919	----------
1895	.08326	----------
1897	.06170	.02950

While the reduction in cost in 1897 has been very great, I aga
result is in the nature of a disappointment to me. So far as
cerned the result has been all that I expected, but the reverse ha
the other costly material, rock.

Experiments are now being made to discover a material th
necessary qualifications and yet be cheaper than rock. It is t
experiments will be successful, but they will take time.

In the meanwhile, by using a small amount of cheap lumb
the interstices in the pockets of the cribs, I think that gravel c
last at localities where gravel can be obtained cheaply, say Nate

I am not prepared to state that spur-dike construction has
lowest cost, although the present season's work was a long ste
At the same time it is well to recollect that the working seas
exceptionally favorable, and such a one may not occur again for

Very respectfully, your obedient servant,

H. S. Douglas, A

Capt. Geo. McC. Derby,
Corps of Engineers, U. S. A.

Appendix 10 F.

REPORT OF MR. H. S. DOUGLAS, ASSISTANT ENGINEER IN LOCAL CH MENT DEPOT, NEW ORLEANS, LA.

New Orleans,

Sir: I have the honor to submit the following report on the
and repair of the plant belonging to the district for the period fr
May 1, 1897.

The plant consists of 62 pieces, as follows: Standard gunwale
inclusive, Nos. 14 to 29, inclusive; framed barge No. 230; gunwal
542, and 544 to 550, inclusive; small gunwale barges A, B, and
scows, 2 small lighters, warehouse barge, dock, pile driver No.
Alaska, and *No. 5*; quarter boats *New Orleans*, *Alpha*, *Beta*, *Gamm*
Tilda and *General Comstock*; steamer *Osceola*; hydraulic dredge
are also 2 camel docks, 1 side dock, pontoons, skiffs, etc.

REPAIRS.

Barge No. 1.—Entire new floor timbers; new stringers over flo
new rakes; knuckle, sides, and rakes calked; old bottom trea
rakes and parts above water line with the New Orleans preservati

Barge No. 2 (mooring barge).—New gunwales, or sides, from wa
new rakes; new head blocks; entire new deck, and old deck bea
floor timbers and new stringers over floor timbers; new timberh
and sides calked; interior of barge treated with New Orleans p

steam capstan was removed from the condemned steamer *General Newton* and, together with a small boiler, installed on the barge. Cost, $2,216.15.

Barge No. 3.—Seven new rake timbers and 18 new rake planks; new ends on bottom gunwale; new floor timbers; new stringers over floor timbers on gunwales and bulkheads; new clamps on bulkheads; all diagonal braces renewed; rakes, sides, and deck calked; old timber in bottom treated with tar; new work treated with New Orleans preservative. Cost, $582.75.

Barge No. 4.—Ten new rake timbers and 35 new rake planks; 1 new end on bottom gunwale; entire new floor timbers, and new stringers on top of floor timbers on gunwales and bulkheads; rakes and sides calked; numerous graving pieces put in gunwales; new clamps on bulkheads; old timber in bottom treated with tar and new work with New Orleans preservative. Cost, $596.

Barge No. 5.—Entire new deck and new deck beams; 11 new rake timbers and 32 new rake planks; 1 new end on bottom gunwale and graving pieces at end of gunwales; entire new floor timbers; new stringers over floor timbers on gunwales and bulkheads; new clamps on bulkheads, and new diagonal braces; entire new set of timberheads; graving pieces were put in sides and rakes; sides and decks calked; old wood in bottom treated with tar and new work with New Orleans preservative. Cost, $1,544.20.

Barge No. 6.—Entire new floor timbers and new stringers over floor timbers on gunwales and bulkheads; 3 new rake plank; diagonal braces taken down and reset; sides and rakes calked; old timber in bottom treated with tar and new work with New Orleans preservative. Cost, $273.98.

Barge No. 7.—Entire new floor timbers and new stringers over floor timbers on gunwales and bulkheads; diagonal braces removed and replaced; 6 new rake timbers and 21 new rake plank; 3 new ends on lower gunwales; sides and rakes calked; old timber on bottom treated with tar and new work with New Orleans preservative. Cost, $474.83.

Barge No. 8.—Entire new floor timbers and new stringers over floor timbers on gunwales and bulkheads; diagonal braces taken down and replaced; 2 new rake plank; rake and sides calked; treatment with tar and preservative, same as other barges. Cost, $331.20.

Barge No. 9.—New floor timbers and new stringers over floor timbers on gunwales and bulkheads; diagonal bracing taken down and replaced; 18 new rake plank; entire new set of timberheads; 5 additional tie-rods between gunwales; large capstan taken off barge No. 2 and placed on No. 9; sides and rakes calked; treated with preservative, same as other barges. Cost, $749.47.

Barge No. 15.—Entire new deck and old deck beams repaired; entire new set of timberheads; deck, sides, and rakes calked; barge had been treated with creosotine in December, 1895; new work was treated with a preparation of one-half creosotine and one-half New Orleans preservative. Cost, $1,002.10.

Barge No. 16.—Entire new set of timberheads; 25 new rake plank; sides and rakes calked. No preservative of any kind has been used on this barge. Cost, $256.07.

Barge No. 17.—Six new rake plank and some small patches on rake; new set of timberheads; sides and rakes calked; treated with sulphate of iron in December, 1895. Cost, $256.06.

Barge No. 18.—Entire new deck; new timberheads; 6 new rake plank; deck, sides, and rakes calked; treated with carbolineum in December, 1895; new work was treated with same preservative. Cost, $984.07.

Barges Nos. 19 to 28, inclusive.—Turned bottom up; bottom planking respiked, calked, and coal-tarred; turned deck up, and decks, sides, and rakes calked; inside of barges thoroughly cleaned out and scraped, then treated with the New Orleans preservative. Cost for the 10 barges, $3,471.86.

Lighter or small barge (part of plant for dredge Ram).—Generally overhauled, calked, and repaired. Cost, $138.26.

Barge B.—Gunwales and deck patched and calked. Cost, $150.45.

Warehouse barge.—Twenty-one new rake plank; 6 long and 9 short floor timbers; new stringers on gunwales over floor timbers; 4 new ends for bottom gunwales; rakes and sides calked; interior thoroughly cleaned and scraped and treated with New Orleans preservative. Cost, $261.73.

Spud barge of dredge Ram.—Deck, sides, and rakes patched; sides and rakes calked. Cost, $68.12.

Dredge The Ram.—Deck and sheer plank patched; hogchain braces and spud-gear frames repaired. Cost, $180.81.

Tug General Comstock.—Repairs to pump; new smokestack and breeching. Cost, $110.

Tug Tilda.—Entire new stem; new planking on bow; foundation under engine repaired. Hull sheathed inside and concrete put in between timbers; hull calked, coal tarred, and painted; new crank shaft; intermediate shaft straightened; additional supply pump installed; furnace altered and rebuilt. Cost, $619.24.

Launch Ruby.—Ten new planks in hull forward and 7 in rake aft; 8 new entire new deck on guards and covering board; new floor and ceiling i entire new roof, new carlins being put in where necessary; entire new molding; entire new set of cavils; entire new wheel; new nosing; new and breeching; supply pump repaired; hull inside thoroughly cleaned and treated with two coats of the New Orleans preservative; hull outside coa painted; new wheel and all of upper works painted inside and out. C

Quarter boat Gamma.—New rakes; 4 new ends on bottom gunwales; ne and new guards, guard rim, and fender streak; graving pieces put in necessary; sides and rakes calked; New Orleans preservative used on al Cost, $668.54.

Quarter boat Delta.—Entire new rake on one end and other rake repai outriggers; new deck, guard rim, and fender streak on guards; gravi sides; rakes and sides calked; New Orleans preservative used on all Cost, $439.04.

Quarter boat Alpha.—Entire new bottom and rakes, including new fl new stringers on gunwales; new center bulkhead, with a bottom streak of cypress; new cavil and sundry repairs to house; bottom, rakes, and s coal tarred, and, together with house, painted. Cost, $470.

Quarter boat New Orleans.—In August, 1896, the hull of the boat was follows: New planking from knuckle to water line; several new frame at one end; all new work was calked and hull coal tarred and pai $1,295.22. In April, 1897, it became necessary to send the boat out on emergency work. After being loaded with lumber, sacks, supplies, etc., in front of New Orleans, and while being towed up the river, the hull fi openings left for ventilation, and the boat sank until only the upper cabin was above water. With the assistance of several tugs the boat on the bank near the Algiers Point. After many and discouraging attem successfully floated and towed to the depot for repairs. The hull wa damaged, but the upper works were entirely destroyed in places. Repai of 100 feet of guard rim and fender streak on hull renewed; entire ne tionery fenders or stanchions; new bitts at both ends; main deck pat new deck and guard rim on guards of boiler deck; new rail and stanchio deck guard; 18 new carlins and 2,000 feet B. M. new flooring in cabi patches on sides of cabin and on bulkheads between rooms; new can boiler-deck guards and portion of hurricane roof; doors and sash refitte where necessary; tables and benches repaired, etc. Cost, $498.95, or, in vious repairs, a total of $1,793.47 for the year.

Pile driver No. 32.—Entire new rakes; entire new streak of gunwales a and other gunwales patched; about one-third of bottom planking re stringers over floor timbers and new foundation for boiler; new head end; new leads for hammer; deck patched and hogchain braces reenforc rakes, and sides calked. Cost, $520.50.

NEW PLANT.

Dock.—Barge No. 13 has been converted into a dock capable of dock *Comstock* or *Tilda*, the launch *Ruby*, pile driver No. 32, and the quarter or *Beta*. The dimensions of the dock are: Over all, 104 feet; in clear, 98 over all, 30 feet; inside, 29 feet. Deck and intermediate bulkheads we from barge; new floor timbers put in; sides or gunwales built up to depth of 10 feet at gate end. Old rake was cut off square at springi gate end and fitted with a gate 10 feet high and 20½ feet wide. Sho built at solid end of dock and a large steam pump installed. Bottom strengthened with two side keelsons 12 by 12 inches and two center ke 14 inches, extending the entire length and bolted through bottom at ea ber. Sides of dock were strengthened with 18 braces 4 by 8 inches by 3 Knuckle seam part of bottom, sides, and rake were calked. Suitabl sinking dock were fitted in place. All floor beams, lower gunwale, k bottom of braces were first treated with New Orleans preservative an tar. All parts above lower streak of gunwale were treated with pres inside and painted with iron-ore paint and rosin oil on outside. Cost, $1

Camel dock.—An additional and larger camel dock has been built of th dimensions: Length, 16 feet; width over all, 39 feet; in clear, 33 fee sides, 9 feet 6 inches; deck to floor, 2 feet 9 inches. Cost, $308.29.

Small pontoon.—In lining in cribs while being lowered in place on ce spurs, running out wire cables for mooring, and toggle lines a small ponto sary. One has been built of the following dimensions: Length, 19 fee feet 6 inches; depth, 18 inches. It was built entirely of cypress, and treated with the New Orleans preservative, to test the effect of the pres cypress. Cost, $111.69.

CARE OF PLANT.

ıead I include not only the pay of watchmen, but such other work and rs as is, in my judgment, necessary for the proper care of the plant. ffs, minor repairs to steamer *Osceola*, and to old barges transferred from trict to fit them out for high-water emergency work, cleaning out , etc., pumping, etc., are included under this head. The crew of one is necessary to keep in commission, is also included. Care of plant as d has cost in round numbers $7,800. The first cost of the plant cared vernment depot is in round numbers $270,000. The amount expended ar for repairs, new plant, and care and maintenance of old is in round 00, or 10.7 per cent of the first cost.

ıas been to put the entire plant in fair condition, in proof of which it l that during the recent high-water emergency practically the entire g some pieces that had been condemned as beyond economical repair, and used at the shortest possible notice.

spectfully, your obedient servant,

H. S. DOUGLAS, *Assistant Engineer.*

C. DERBY,
ps of Engineers, U. S. A.

APPENDIX 10 G.

R. A. F. WOOLLEY, JR., ASSISTANT ENGINEER IN LOCAL CHARGE OF IMPROVING ATCHAFALAYA AND RED RIVERS, LOUISIANA.

NEW ORLEANS, LA., *May 1, 1897.*

have the honor to submit the following report upon the work of improv- ya and Red rivers, Louisiana, under my local direction, for the period 896, to May 1, 1897:

DREDGING OLD RIVER.

: New Orleans August 31, with coal barge and four pontoons. Arrived September 4. Began dredging on first cut September 5; completed ptember 17. Began third cut October 31; completed third cut Novem-

ason has been one of the most favorable for maintaining low-water rough Old River at a minimum of cost. There was no extremely high the season and there was a period of about one hundred and fifty days, 1 to June 25, during which there was something like a half-bank stage a strong current from the Mississippi toward the Atchafalaya, keeping he dredged channel through Old River pretty thoroughly scoured out, e from any great amount of silting.

edging required in Old River proper was across the bar at the mouth this work was on the same channel line used last season, shaped like rcle, its outer end pointing directly up the Mississippi and the inner directly down Old River. As mentioned in last annual report, the s this bar was shaped in this manner to more readily accommodate a from the Mississippi toward the Atchafalaya, a condition that most ists during low water. This channel was cut to a width of 100 feet h corresponding to a zero stage for Barbres and Red River Landing e portions of this channel required only a light, single cutting; other red three cuttings.

ys of ten hours actually dredged on three cuttings	13.8
channel dredged, a portion of which required three cuttings	650
bic yards dredged, three cuttings	17,390
ber of cubic yards dredged per working hour	126

DREDGING HEAD OF ATCHAFALAYA RIVER.

ıe long period during which there was a strong flow through Old River sissippi toward the Atchafalaya, to the low stage of water in the and to the consequent result of the two above-named conditions, it was lredge a channel 350 feet in length through a bar which formed in the River about 500 feet below the United States depot at Barbres.

ys of ten hours actually dredged	2.3
bic yards dredged	3,200
bic yards dredged per working hour	139
channel dredged	350

RECAPITULATION.

Atchafalaya and Old rivers.

Total number of days of ten hours actually dredged..............
Total number of cubic yards actually dredged..................
Total cost of material actually dredged.......................
Average cost per cubic yard of material dredged................

It will be noted that the average of material handled per worl
Atchafalaya and at the mouth of Old River differ by about 10 pe
being the smaller, due to the fact that the work there was usually
deepening of an insufficient channel, where the dredge was seldor
mum depth of cut throughout the full width of channel. It will a
the cost per cubic yard of material handled this season is in excee
This is accounted for in view of the fact that the expense of carr
the scene of operations and bringing it back after work was cor
to several days, and is the same for a long or short season's work.

DRAINING LAKES NEAR OLD RIVER.

There are a number of lakes in the old bend of the river in the in
of Old River. These lakes hold from 4 to 12 feet of water each.
these lakes are from 15 to 25 feet above the zero of Barbres gauge
the banks of Old River from caving I have had these lakes c
annually for the past four years.

The smaller lakes were drained the past season by hand, but the
lakes was within 800 feet of Old River. A force of men sufficient to
lake by hand could not be obtained in time. The *Ram* was moved
and her discharge was trained against the bank between Old Riv
22,000 cubic yards was moved in this way, and the lake thorough
of two working days.

ATCHAFALAYA SILL DAMS.

The construction of these dams was commenced in 1887 and co
The structure consisted of alternate layers of willow mattresses, stif
or stone.

Gravel was used in sinking a number of mattresses when no str
vailed.

These structures are all in a comparatively good state of repair.
tions have become badly decayed where not covered by silt, though
tance need be attached to this, as the bank is pretty thoroughly p

The subaqueous portions of these structures are undoubtedly stil
gradually being endangered by the scour and increasing depth belo

Four longitudinal sections over each dam have been platted from
in December, 1894, December, 1895, and December, 1896.

A longitudinal section over crest of each dam is platted from
December, 1894, December, 1895, and December, 1896, for direct comp
tion of river bed before construction of dam and longitudinal sect
dam immediately after completion.

Contours, embracing dams and vicinity, have been platted from
December, 1894, December, 1895, and December, 1896. By a glance at
section of crest of dams it will be noted that their settlement ap
closer relation to the increase of depth below each dam than to a sl
tionate to the height of individual dams.

By a comparison of contours from soundings in December, 1894,
1896, it will be noted that contours of 1896 show a decided silting
above the dams, between the dams, and below the dams.

The greatest silting in the vicinity of dams, and below Dam No.
feet.

This silting in the bed or channel I attribute to the long period
season, during which there was a medium stage of water in the Mis
water in the Red, resulting in a very strong flow toward the Atchaf
large per cent of deposit. The volume of water turned into the At
Red and by Old River, from the Mississippi, was sufficient only to
gentle current in the Atchafalaya, thereby causing the silt from the
deposited in the Atchafalaya. A very marked demonstration of thi
be had from the fact that it was necessary during the month of
dredge a channel across a bar in the Atchafalaya, near its head, wh
feet or more had been known to prevail for a number of years.

I therefore consider this silting in the channel of the Atchafalaya only a temporary condition, one which will be removed by the first stages of water necessary to produce a strong current in the Atchafalaya, and am satisfied that the ultimate safety of the sill dams in the Atchafalaya is only to be secured by additional work in their vicinity.

I am of the opinion that Dam No. 1 (upper) is as yet in no wise endangered, but that Dam No. 3 is threatened; that a survey in the vicinity of the dams should be made soon after the 1897 high water subsides, and if it develops that the silting mentioned above has been removed and there is a tendency to scour to a greater depth below dams steps to preserve same should be taken at as early a date thereafter as practicable.

Should the removal of silt as predicted above take place, I am of the opinion that for the preservation of Dam No. 3 a pavement of willow mattresses, between low-water shore lines and extending on an average of about 300 or 350 feet below the lower edge of the floor mattress or sill of the dam, is considered necessary.

This pavement of willow mattresses may not extend downstream a greater distance than 200 feet near shore line, but should extend about 400 feet downstream, out in the channel, to reach deep water, and to protect those places from scour which have proved to be most likely to suffer from this cause.

It is by no means improbable that, after the lower dam is secured, no greater scour will take place below the upper dam, or at least not enough to endanger that structure. The willows for a pavement of mattresses could be had near at hand, about 5 or 6 miles. The rock would not be so easy of access and would have to be brought from a distance and at a price probably somewhat in excess of rock delivered at Natchez or at New Orleans Harbor. The willow mattresses need not be more than 26 inches in thickness.

The amount of willow mattresses required will be 245,000 square feet or less, at a total cost of $19,600 or less, in place.

Very respectfully, your obedient servant,

A. F. WOOLLEY, JR., *Assistant Engineer.*

Capt. GEO. McC. DERBY,
Corps of Engineers, U. S. A.

APPENDIX 10 H.

REPORT OF MR. A. F. WOOLLEY, JR., ASSISTANT ENGINEER IN LOCAL CHARGE OF DREDGING FORDS CROSSING.

NEW ORLEANS, LA., *May 1, 1897.*

CAPTAIN: I have the honor to submit the following report upon the work of dredging Fords Crossing, under my local direction, for the period from May 1, 1896, to May 1, 1897:

A survey was made at Fords Crossing between September 10 and 12 to determine the location of the proposed channel and the extent of the work to be done.

The survey showed the greatest depth over the bar at that date to be 6.4 feet below low-water plane, though the least depth below low-water plane within the limits of anything approaching a plausible location for a channel, or one which after being dredged would most likely maintain itself with the minimum amount of work during the season, was only 4.4 feet.

The ram left Old River for Fords Crossing September 21, 1896, with four pontoons, coal lighter, and a large fuel barge; arrived at Fords Crossing September 22, 1896; began actual dredging September 28, and completed first cut October 13.

Number of cubic yards moved in first cut	14,750
Number of working days of ten hours consumed on first cut	8.94
Number of cubic yards moved per working hour on first cut	165

Commenced the second cut October 14, 1896, and completed the second cut October 22, 1896.

Number of days of ten hours actually worked on the second cut	4.55
Number of cubic yards actually moved from second cut	7,510
Number of cubic yards moved per working hour from second cut	165
Total cubic yards moved from channel through crossing	22,260
Total cost of work at Fords Crossing	$1,964.81
Average cost per cubic yard for work at Fords Crossing	$0.0882
Length of channel dredged ... feet	1,900

The season was not the most favorable one that could have been asked
of the permanency of this dredged channel, as the water did not fall wit
of extreme low-water plane, began rising a few days after dredging was co
continued to rise throughout the entire course of the work and for a numbe
thereafter.

The dredge was worked at a depth of 12 to 12.5 feet below extreme low
width of channel dredged was 100 feet, and it was hoped that a depth of
to 11 feet below low-water plane for a width of 100 feet would be maintai
after all dredging was discontinued. This did not prove to be true wit
river. I am of the belief that it would have been very nearly if not quite
a continuous falling river.

It was known that the ram left a back fill of something like one-half to
extent of the back fill varying with the class of material, being practicall
for stiff clay and increasing as the material approached a coarse grade of

The material found at Fords was coarse sand and gravel, which ran
very freely. I took a number of samples of material from different pa
channel throughout the course of the work, and it is worthy of note that th
from the upper end of the channel were very coarse, full of large gravel,
ually becoming finer throughout the entire length of the channel as the l
was approached.

Although the average number of cubic yards handled by the ram per
hour at Fords was in excess of that handled in Old River, I am of the opi
she is too small a machine to cope with the magnitude of the ordinary ba
the Mississippi.

I am confident that the system of operating the ram by using heavy a
holding bow swing lines could better be replaced by jetted piles for wo
open Mississippi; this would obviate the great length of swing lines, wea
on swing lines, heavy strain on spud required to hold swing lines in stron
and consequent loss of power in operating bow winch engines necessary to
this dead strain. The launch *Ruby* was not available during the entire p
the work, but was used as a tender to the ram during the latter half of t
and proved to be an invaluable adjunct in handling swing lines, anchors, f
ers, and making soundings in channel ahead of and behind the dredge. T
this work was much in excess of what it would have been had a tender be
able all the while.

The cost per cubic yard of material handled, with the *Ruby* as a tender th
the entire work, would have been $0.056, or less.

It will be seen from the sketch showing the location of channel at Fords
upper end of channel is located in best water above the bar, the lower en
water below the bar, and the dredged channel straight throughout its enti

At a casual glance the "crossing" would appear to be entirely too abru
one not familiar with the local conditions. This location and course for
channel received very careful consideration, upon information obtained fro
before work was begun, the course of channel being determined by runni
ber of floats from upper to lower end, to have the flow parallel to channel
practicable.

Very respectfully, your obedient servant,

A. F. WOOLLEY, Jr., *Assistant E*

Capt. GEO. McC. DERBY,
Corps of Engineers, U. S. A.

APPENDIX 10 I.

REPORT OF MR. W. J. HARDEE, ASSISTANT ENGINEER, IN LOCAL CHARGE
LOWER TENSAS, ATCHAFALAYA, LAFOURCHE, AND PONTCHARTRAIN LEVEE DI

NEW ORLEANS, LA., *May*

DEAR SIR: I have the honor to submit the following report for works
local direction for the year ending May 1, 1897:

GENERAL METHODS.

Construction.—During the year construction forces were steadily engage
district or another until March, when high water interrupted work. At th
this report a large amount of work is under contract, which will be prom
tinued as soon as stage of river will permit.

A tabulated statement for each district is herewith submitted, and furnishe
information for all levees built and constructing.

Tile drainage.—No tile drains were laid during the year, but the high stage of water in the river furnished an excellent opportunity to observe the workings of those put down several years ago. I personally inspected some, while others are reported by inspectors. In every instance where the plantation ditches, bayous, sloughs, or depressions into which they discharge furnished adequate drainage, the tiles most admirably and efficiently performed the service for which they were designed; they obviated the necessity for open seepage ditches at the land base of the levee and kept the back or land slope thoroughly dry.

I am convinced of the practical value of tile drains for removal of seepage water, and believe the entire levee system would be greatly benefited by their application. This, however, is not practicable at this time, owing to the absence of competent outlets into which to discharge them.

Muck or base ditches.—The previous custom of cutting muck or base ditches was continued at such localities where existing embankments were known to be leaky. The leaks are usually due to holes or cavities made through or under the embankment by burrowing animals, or partly decayed logs or other vegetation not removed from the surface of the ground, or just beneath, or placed in the body of the levee at the time of its construction. All leaks or cavities were carefully traced and destroyed within the limits of the embankment.

Repairs.—During the months of June, July, August, and September, 1896, all United States levees were repaired and put in good condition; repairs consisted of cutting and removal of weeds and other objectionable vegetation, restoration of rain and wave wash, resodding where grass had failed to grow, and restoring impaired drainage of borrow pits.

Supervision.—There was no material change in the previously reported method of supervision. There was one surveyor at $125 per month whose principal duty was to attend to all instrumental work incidental to construction in the Atchafalaya, Lafourche, and Pontchartrain districts. From time to time as other duties allowed he made surveys for proposed work.

A number of inspectors were employed at $90 and $75 per month and stationed at a levee during the time of its construction. It is the duty of these men to remain upon the levee at all times during working hours, see that the specifications are observed, and keep a daily record of force and operations and submit a weekly report of same.

In the Lower Tensas district there was no traveling surveyor; the inspectors were furnished with a level and required to give grades and report completed contracts. From time to time as the opportunity presented itself I verified the instrumental work of the inspectors.

Inspection.—The previous custom of making inspections by railroad, steamboat, or buggy or horseback was greatly improved by the introduction and use of the bicycle.

It was found that, due to lack of inexpensive facilities for getting about, our cost of inspection, particularly that part directly connected with construction, was unsatisfactorily large.

By using a bicycle an inspector could cover enough territory to care for two or more levees, or in fact any number of contracts within the limits of ten miles. The bicycle was experimented with and the results were so satisfactory that it was considered advisable to make it a part of an inspector's equipment.

The high-grade inspectors were therefore notified that they must possess and use a bicycle after January 1, 1897, as a condition of employment. In all 18 inspectors purchased and are using bicycles.

By the use of mine I am able to cover an immense amount of territory in a short time. I have frequently inspected as much as 30 miles in one day, including stops for detailed observations.

The tops of the embankments usually furnish good riding and afford advantageous position for inspection, as the entire top and both slopes are visible to the rider.

LOWER TENSAS LEVEE DISTRICT.

Assistant Engineer H. S. Douglas was transferred from this district to New Orleans Harbor during September, 1896, and I was placed in charge. At that time no work was in progress but surveys had been made and about 675,200 cubic yards of raising and enlargement were under advertisement. It was at first proposed to improve all the existing levee at Evergreen (633 R) in this manner, but it was afterwards decided more advisable to remove a portion of the line from close proximity to Lake St. Joseph; accordingly 710 linear feet of new levee was built.

When bids were opened, it was found that contracts for all of the advertised work could not be made owing to insufficiency of funds; some bids were therefore rejected, the necessity for the immediate improvement of the existing levee and prices bid governing the rejections.

The work was advertised for a net grade of 3 feet above 1890 water, but by arrangement with the contractors for all but the Ashley to Fairview Levee (726 R), the grade

was raised to the 5-foot plane. The time for completion was extended in p
the increase of quantities; originally advertised yardage to be paid for
completion of entire work and the increased yardage to be paid for whe
of the 1897 allotment would become available. It so occurred that all le
one near the lower end of the district, were built to a net grade 5 fee
water.

The aggregate length of the contracts is 113,342 linear feet, or 21.47 mile
990,279 cubic yards, of which 55,066 linear feet, or 10.43 miles, embr
cubic yards, were completed, when operations were suspended on acc
water.

There was 968 linear feet of levee abandoned during the year by cons
new line by the United States; local authorities built no new levee.
feet of embankment was destroyed by crevasse at Glasscock (725 R), a
to be rebuilt during the coming year.

Of the total 678,910 linear feet, or 128.58 miles, of effective levee on
there are 433,406 linear feet, or 82.08 miles, built wholly or in part and pa
United States. The small net increase of levee built wholly or in part b
States is due to the fact that about one-half of the work done during
upon levees previously enlarged or originally built by the Federal Gove

ATCHAFALAYA LEVEE DISTRICT.

In addition to the levees under contract but incomplete at the dat
annual report, other contracts were made until the annual allotment wa

The major part of the work done during the year consisted of raising a
existing levee; only one short length of new embankment was built.

During the year construction of new levee by the United States at Al
and Belmont (825 R) ocasioned the abandonment of 1,367 linear feet of d
embracing 17,000 cubic yards. Of the total 675,929 linear feet, or 128
effective levee on May 1, 1897, there are 431,087 linear feet, or 81.28
wholly or in part and paid for by the United States.

LAFOURCHE LEVEE DISTRICT.

Work upon the incomplete levees named in my last annual report wa
Additionally, other contracts were made to the extent of the balance c
allotment.

All the work done during the year was raising and enlargement of existi
ment; no new levee was built.

Of the total 433,245 linear feet, or 82.05 miles, of effective levee, there a
1897, 256,043 linear feet, or 48.49 miles, built wholly or in part and pai
United States. Heretofore Company Canal (958 R) has been considere
end of this district, and from Company Canal to Jefferson-Orleans parish
of the Barataria district. These limits were recently changed and this
a part of the Lafourche district, which accounts for the increased lengt
levee over that previously reported.

PONTCHARTRAIN LEVEE DISTRICT.

As in the two preceding districts, work upon contracts unfinished at
my last annual report was continued and additional contracts made to t
the balance of funds.

All but a very small amount of the work done consisted of raising an
existing levees. During the year construction of new levee by the U
at Gomez (855 L) and Boisblanc (952 L) occasioned the abandonment of
feet of district levee embracing 38,000 cubic yards. Of the total 662,89
or 125.55 miles, of effective levee on May 1, 1897, there are 469,944 line
miles, built wholly or in part and paid for by the United States.

HIGH-WATER PROTECTION.

As early as March 9, 1897, the flooded condition of the Ohio and its
having made it apparent that a high stage of water would soon follow
sissippi at Vicksburg and south of there, steps were taken to prepar
for the flood as well as arrange an organization for their maintenanc
continuance.

The Fifth District Levee Board had just completed raising and enlar
between the north end of Lower Tensas district (Bedfords, 606 R) and
(633 R), a length of 36 miles, to a net grade of 5 feet above the (1890
highest known water.

The United States had 14.4 miles of raising and enlarging to the grade just named under contract at six different points between Hard Times (633 R) and Vidalia (701 R), of which 8.2 miles was completed. When these contracts were made in September and October, 1896, the work was advertised for a grade 3 feet above 1890 water, but before work was commenced an agreement was made with the contractors whereby the grade was raised to the 5-foot plane, payment for the additional yardage to be awaited until the balance of the 1897 allotment would become available.

The latest of the advertised dates for completion was March 1, 1897, but an extension of time corresponding with the increase of yardage formed a part of the agreement for raising grade. This accounts for nearly one-half of the contracts remaining incomplete when the river left its banks and operations were suspended.

The initial step in the direction of preparing for the advancing flood consisted in having our contractors immediately put all their forces to work "capping" the unfinished lengths of their contracts. The "capping" consisted in putting a new top on the existing levee. The new top occupied the full crown width of the old embankment and was brought to an elevation 3 feet above the 1890 water, at which grade it was made as near 4 feet wide as the width of the old crown and steepness of slopes would allow.

There was so much "capping" to do and the forces were so limited that it was considered advisable to anticipate the river well in advance to insure completion of the work by the time the flood would arrive.

Batt O'Brien was delinquent on his Evergreen Levee contract, and so was Garbish & O'Neil on their Harper Levee contract. As they were delinquent, they were deemed responsible for the insecurity of the levee and were required to "cap" their unfinished lengths at their expense. They did so, the former amounting to 4,800 linear feet and the latter to 1,400 linear feet.

There was no responsibility resting upon Charles O'Donnell for the incomplete 5,600 linear feet of Winter Quarters Levee, on James G. Boney for the incomplete 10,200 linear feet of Bondurant Levee, on Charles D. Leeper for the incomplete 2,400 linear feet of Cottage Home Levee, nor on Manning & Gibson for the incomplete 11,000 linear feet of Rifle Point Levee. Their forces were engaged to do the "capping," and were paid $3 per day for each team with driver, $2.50 per day for foremen, and $1.50 per day for each extra laborer. The "capping" of the foregoing 29,200 linear feet cost $3,156.25. Work was commenced on Winter Quarters on March 12 and finished on March 22, on Bondurant on March 14 and finished on March 19, on Cottage Home on March 12 and finished March 18, and on Rifle Point on March 13 and finished on April 4. When Cottage Home and Rifle Point "capping" was completed, the contractors' forces were engaged at same rate of pay and capped adjoining lengths of low levee. The former amounted to 1,400 linear feet and cost $109; the latter 6,450 linear feet, and cost $636.

The next step, after having commenced the "capping," was to correspond with the Fifth District Levee Board, advising them of the limited available high-water protection fund, inviting cooperation, and suggesting, as the most efficient method of applying its small fund, that the United States supply a few tools and a small amount of material, to be placed on barges to be stationed about 15 miles apart throughout the district, with a steam craft of some description to move them as work might require. The suggestion was adopted by the levee board, and you directed me to at once attend to purchase of materials and tools, as well as get boats ready for departure.

At noon on Friday, March 19, a tow of 9 barges left the Exposition Wharf. On each barge there were 24 wheelbarrows, 24 shovels, 6 axes, 3 hatchets, 1 handsaw, 1 crosscut saw, 6 mattocks, 2,000 empty sacks, 2 kegs wire nails, 2 hand lanterns, 2,000 linear feet of 2-inch wheeling plank, and 200 barrels of coal.

An inspector was stationed with each barge to care for it and look after the supplies on it. These inspectors had local charge and supervision of the work done and paid for by the United States in the vicinity of their barge. They also rendered service in advising with and directing the local forces when called upon to do so.

The barges were towed by the United States steamers *Osceola*, *Ram*, and *Ruby*. Two days later the U. S. tug *Comstock*, which had been undergoing repairs, proceeded up river, joined the tow, relieving the *Ram*, which returned to New Orleans for other duty. The tow was too heavy to make satisfactory progress, and the tug *Mamie Coyle*, of Baton Rouge, was chartered on March 25, and, joining the tow below Baton Rouge, assisted in moving it to its destination.

I joined the boats at Baton Rouge on the evening of March 22, and the next day, not being satisfied with the progress we were making, broke up the tow and gave a number of pieces to each boat, depending on its estimated capacity. Progress thereafter was 25 per cent faster, the boats moving along at about the same rate and all keeping within sight of each other.

At 5 p. m., on March 26, first barge was moored at Greens Landing (720.5 R), its destination. The next morning another barge was placed at Morville (710 R), at

noon one at Vidalia (701 R), where the *Ruby* remained for duty; durin
noon one at Bullitts Bayou (692 R), and at dark another at Waterproo

At noon on Sunday, March 28, St. Joseph was reached with three b
Commissioner C. C. Cordill advised me that no barges were required
north of St. Joseph, but were wanted a few miles below. At his req
barges were temporarily moored at St. Joseph. The *Mamie Coyle* and
returned to Baton Rouge for orders; the *Comstock* remained at St. Jose

On the way up the river I had inspected portions of the levee line on
first move was to thoroughly inform myself as to the condition of the
well as what local organization existed and work was in progress. Thi
a personal inspection, which was made by bicycle. I ascertained th
were guarded night and day in beats of 2½ miles each by men emp
parish police jury under the direction of the juror for respective wa
during the flood, as bad places developed, a special night and day man
to watch each.

From Bedfords to Hard Times the line was in excellent condition, h
of 55 or more feet on the Vicksburg gauge, with corresponding cross se
Hard Times to Vidalia the line was of varying height and cross sectio

The only work in progress, in addition to the "capping" we were hav
the raising and strengthening of some banquets at Bondurant (643 R)
(644 R), which was under the direction of the levee commissioner and
by the Fifth District Levee Board. This work was considered necessa
of the sandy character of the soil and its well-known disposition to s
vide against which the existing banquets were raised and widened s
seepage to a minimum.

I conferred with Levee Commissioner Cordill, and the parish authori
in maintaining the levees, and the opinion was almost unanimous tha
52 feet would be reached at Vicksburg from the water then in sight at
with the prospects of even more, as the Ohio was still rising and the
low and likely to come out and augment the flood at any time.

Much of the levee line, as it then stood, could not successfully hold su
water, and though Vicksburg read only 48.8, compared with its recor
Joseph 44.1, compared with its record of 45.15, and Natchez 45.8, com
record of 48.60, it was decided to immediately commence raising th
embankments, which were less than 3 feet above 1890 water.

On March 31 you wired me, asking if I did not consider it advisable
of the line south of Vidalia. As the prospects indicated my full atten
required north of Vidalia to hold the line, I wired in the affirmative, a
Hoffman arrived a few days later and took charge.

The first work commenced was at Kempe (657 R). This is a very large
to 22 feet high, extending about 5 miles through a dense swamp, a
isolated, as there are no settlements along its length, and conseque
available in its immediate vicinity. Additionally, the swamp wa
cedentedly dry, but could in a few days be inundated by rain or seepage,
important to take advantage of its favorable condition, and the fur
labor could be brought there, as it was not required just then elsewh
of this levee varied from 2½ to 3½ feet above 1890 water. It was decid
make it secure for 52 feet on the Vicksburg gauge, but also provid
safety and a grade equal to 54 feet was adopted.

Several contractors' outfits, aggregating about sixty teams, were
put to work. It was a long line to raise and the time in which to do it
was evident that the teams could not work if several hard rains would
intervals, which, together with the great importance of providing ag
being overtopped, decided Commissioner Cordill to put a force of 1
work cutting away the land-side edge of the crown and pyramiding i
or remaining half of the crown. All this was done within three da
following and restoring the disturbed section, as well as compacting t
and adding required material to bring the entire new top to the 54-fo
gauge) grade with a 4-foot crown. More than four weeks were cons
pleting the team work, but it was finally finished a few days in advan
imum height attained by the flood. It was a great undertaking, but
plished, only, however, through the fortuitous circumstances of good
is rarely the case teams can be worked to any advantage or make an
progress in a timbered swamp behind an embankment in the spring
rains are usually experienced. It would have required a small army o
done this work with wheelbarrows, owing to the great height of the em
the character of untrained plantation labor which was all that was
all the plantation labor was so shortly afterwards required at othe
quite certain that had it not been for the availability of the levee o
and the good weather which prevailed, the Lower Tensas district lin

would not have been put in the excellent condition the maximum flood height found it; either Kempe or some other levee must have suffered neglect.

The work done at Kempe is considered so great an accomplishment, everything considered, that I deem it proper to give it the above extended notice.

A few days after work at Kempe had been commenced, the breaks in the Mississippi levees occurred. I again conferred with Commissioner Cordill and the parish authorities, and found it was their general belief, as well as my own, that if the west bank levees would hold, at least 54 feet at Vicksburg could be expected. Our levees were in no condition to stand this height, and to provide for it meant prompt action and much work. Thanks to the intelligence, energy, and public spiritedness of the people of Tensas Parish, it took but a few hours to organize for a 54-foot (Vicksburg) gauge campaign. Fortunately, such grade had been established for Kempe, and the work already done there would not require going over. Another fortunate circumstance was the interpretation of your instructions by our inspector at Evergreen Levee, who had had the capping put to the 54-foot instead of 52-foot grade, so that the 4,800 linear feet there would require no additional raising.

At Winter Quarters the swamp was more or less filled with seepage water and but little dirt was accessible, that which was, generally had to be hauled a long distance. Owing to the height of the levee, inaccessibility of earth, unskilled labor, and the frequent shifting of wheeling runs, which would be occasioned by the small amount of earth necessary for each linear foot of "capping," it was decided to give the levee the additional height with sacks filled with earth, many of which had to be transported a long distance by barge. The sacks were placed two abreast, and from two to four high, as the irregular top of the levee made necessary to establish a uniform grade.

Fortunately, the majority of our inspectors in this district had leveling instruments and I had the entire line leveled, and at intervals of about 200 feet grade stakes were set which enabled the force to work intelligently and economically as the desired grade was always attained and no more work than necessary done.

At the same time the inspectors established water gauges referred to Cairo datum plane, at intervals of 1 mile, for the purpose of closely measuring the flood surface as it touched the embankments. In the case of salient angles or spurs of old levee, producing abnormal precipitation, a gauge was established 200 feet each side of it. These gauges were read when the river reached its maximum stage, and furnished the first high-water plane very closely and accurately determined, and will be of invaluable assistance in establishing future levee grades.

As it was believed the engorgement, which would occur at Vicksburg, resulting from the return wave out of the Yazoo Basin, would dissipate as it traveled down stream, it was not deemed necessary to raise the line to as high a grade in the lower as the upper part of the district. For this reason, and the further fact that to raise the line to a grade of 5 feet above 1890 water in the lower part of the district would entail more work than was probable could be accomplished before the full height of the flood would be experienced, and there would be no advantage in having part of the line to a high grade if long lengths remained low, it was, therefore, decided to work on the 5-foot grade as far down as Goldman; from Goldman to Vidalia to a 4-foot grade, which could later be gone over should the height of the river require.

Between Winter Quarters and Goldman a large number of wheelbarrows and teams were employed and the work of raising pushed as rapidly as possible.

On April 2, I made a bicycle inspection of the line from Goldman to Ferridays on Lake Concordia, a distance of 28 miles. At L'Argent I found a force of teams employed by the Fifth District Levee Board, under direction of Commissioner B. B. Parham, raising the 1,100 feet of levee from Bayou L'Argent north. At L'Argent store I met Commissioners Parham and Hiserodt, as well as several prominent gentlemen of Natchez, who had just completed a two days' inspection of the levees between Natchez and L'Argent. They were not disposed to believe the gauge would go higher than 51 feet at Vicksburg, but appreciating the responsibility resting upon them, were open to suggestions and advice. I had them join me on the *Comstock* at Ferridays, and from there we went to Natchez. It is pertinent to remark that Concordia is largely a nonresident ownership parish. The plantations are operated by managers and the owners live elsewhere; many of them reside in Natchez. At Natchez a conference was held and the situation reviewed and discussed. The longer it lasted the more Mr. Wilmer H. Shields and myself were able to impress the commissioners and other interested persons with the prospects of a high stage of water. They were finally converted to our way of thinking, and decided to act promptly and energetically.

The commissioners communicated with you by wire, and when they learned you could do no more than furnish material, they decided upon a line of action. A proclamation addressed to the people of the parish was immediately issued, notifying them of the situation and requesting that they send their animals and labor to the levee line on Monday morning, April 15.

Between Aquasco (678 R) and Gibsons Landing (683.5 R), a dista
line of less than 8 miles, there were 512 men and 30 teams at work
A few men and teams were also at work between Gibsons Landing
owing to absence of materials and tools work was not actively com
days later, when about 400 men and a few teams were put to work.

The forces were kept working everywhere until Biggs crevasse
falling river at Vicksburg indicated the highest stage had been
time nearly all of the work contemplated had been completed,
lengths here and there remaining, which would have been finished i

All raising was stopped and attention devoted to caring for wav
and leaks.

The crevasse at Biggs appeared to demoralize nearly all of the pl
of the levee officials, and for a few days I feared this demoralizatio
breaks in the line between Hard Times and Vidalia. The fall in th
the crevasse, though it was only nine-tenths of a foot at Vicksbu
half tenths at St. Joseph, and correspondingly less below, occasio
improvement in the condition of the levees. They, of course, appea
the water, but more particularly the leakage became far less and
sloughing stopped doing so and commenced to dry out. This impro
with the anxiety of the planters to protect their land from over
private levees around their plantations, diverted and engaged th
that for a few days the main levee was almost wholly abandoned w
that the day and night guard was maintained. This general den
withdrawal almost resulted in several breaks, but when the river co
again at Vicksburg and the levee recommenced sinking at Winter
a blowout threatened by a 6-inch stream of water bursting through
(644 R), several dangerous sloughs at Waterproof (663 R) and
levees, and the crown collapsed from a cavity and the water ran th
at Mill Bayou (691 R) on Lake Concordia, and a dangerous lookin
occurred farther down the lake, they awoke to the importance of
attention to the front or main line of levee if they would still save
disaster there. From this time on until a subsidence of the flood
promptly and continuously received every attention required.

The work done on the levees during the flood may be classified as
age of base for removal of seepage water; raising grade; washboa
wash of new top work; revetment to arrest wave wash.

CONSTRUCTION OF SPURS TO PREVENT EROSION OF EMBANKMENT AT

Stoppage of sloughs.—A brief description of the work done und
heads is deemed all that is necessary to intelligently explain the st
done which follows. The several kinds of work were done at differe
to describe what was done at each length of levee would make a
much of which would be repetition.

Drainage.—When the water has stood against an embankment
there is always a considerable transpiration, or, as it is more comm
"seepage." This is a percolation of the river water through the por
ment. As the height of water is prolonged or increased, this
greater, for if the embankment be composed of light material th
wash of the particles, thereby increasing the size of the pores u
miniature channels. Seepage produces a general softening or "
land slope, the material at this point oftentimes becoming semi
slope be steep a part of the embankment will slough or slide out, p
sponding loss of cross section. I have never known a first slough
up than one-half of the slope of the levee. If the slough be not
will occur higher up as soon as the exposed surface of the first has
a semifluid condition; the action will continue in steps until the
sloughed across the entire section as far as the water.

To provide against sloughing, a ditch is cut at the base of the
numerous small trenches leading down the slope into it. These tre
take off the water about as fast as it comes through, and not allo
the land slope of the embankment does not usually become water-s
and sloughing is obviated. Ditches and trenches were cut ne
throughout the district.

Raising grade.—Wherever the top of the embankment was less th
it was estimated the water would attain, it was raised and brought
height, the grades adopted, and their limits have been stated.

As far as the available scraper forces could do it, the embankment
teams. The raising consisted in occupation of the crown only wi
which was brought to desired grade with a 4-foot crown. It was

sible, however, to secure a 4-foot crown, as in some places the new dirt had to be raised so high that keeping its base on the old crown and giving it steepest possible slopes, it could not be made wider than 2¼ feet at the top.

But as the team forces could not do all the raising necessary, the other portion was done either by wheelbarrows or sacks. Generally where the material to be used in the topping was good, stiff dirt, such as clay or buckshot, wheelbarrows were used, but this was not always the case, because the long line of levee to be raised in a short time, scarcity of wheelbarrows and run plank, together with the long time it takes to do the wheelbarrow work incident to the frequent shifting of wheeling runs, particularly on high levees, precluded opportunity of doing all raising other than that accomplished by teams with wheelbarrows. Consequently a considerable length of levee was raised with sacks filled with earth. This work was done by placing two sacks abreast near the river-side edge of the crown, forming a base two sacks wide. Additional rows of sacks were placed on those two bottom tier until grade was reached; all joints were broken to minimize leakage. The triangular space formed by top of sacks and land-side edge of crown was then filled in with earth moved by hand or wheelbarrows and well tamped with hand maul.

At some localities where the exposure to wave wash is great and the soil is sandy, based on previous experience, it was deemed safest not to rely on the "washboards" protecting the new top dirt. The planking can not be so closely joined to the embankment as to entirely obviate under wash, which in a short while causes the dirt behind the plank to cave and wash out; it must then be replaced or sacked, making it finally expensive as well as dangerous in the event of a protracted storm. For this reason about 7 miles of the Lake Concordia levee was sacked from one to three tier on the front and then backed with earth. The waves might beat against the sacks for hours without doing damage.

The writer had charge of the 12 miles of Lake Concordia levee during the flood of 1884. The water attained an elevation higher than the levee and was held by planking backed with earth. A wind and rain storm started one Sunday morning and by night there were five breaks, and our defense was so badly battered along its entire length that it was most surprising that there had been so few breaks.

Washboarding.—In all cases where water got high enough to get against new top work done with wheelbarrows and in many places raising done by teams, it was found necessary to drive 2 by 2 inch vertical stakes near the water's edge to which were nailed horizontal inch boards to break the waves and prevent erosion of the new dirt; these boards were placed from one to three high, depending on the extent of top dirt and exposure. They averaged two high.

Revetment.—At Point Pleasant (624 R), Cottage Home (649 R), and Harpers (652 R) there was no timber growing in front of portions of the levee, but instead a wide field exposing the levee to the full action of waves during stormy weather. These levees had only been recently completed, and being composed of light sandy material and having no grass covering, they washed rapidly under wave action. It was deemed necessary to check the erosion which was threatening to cut through the entire section. The revetment was of the roughest construction, being intended for temporary service only. It consisted of 3 by 3 inch scantling driven into the slope of the levee at the water's edge with batter toward the crown. The uprights were placed about 8 feet apart, and each had a 2 by 6 inch brace extending from its top over to the crown of the levee and there fastened to a 3 by 3 inch anchor driven into the crown. This frame was securely nailed and then inch boards placed horizontally were nailed to them, the bottom board being well pushed into the slope of the levee a few inches below the water surface and the planking brought about 3 feet above water surface to prevent overtopping by high waves.

Spur dikes.—At Point Pleasant (624 R), Evergreen (636 R), Bondurant (643 R), Cottage Home (649 R), and Rifle Point (687 R) there are salient angles in the levee line. The water flowed by these angles with such velocity as to erode the embankment, and would in time have entirely destroyed it if the current were not deflected and the erosion checked. The worst cases were Point Pleasant and Cottage Home, where an old piece of embankment extended a half mile or more from the angle out toward the river at something like right angles to its axis. The flow of water was checked by these old levees, raising it to an abnormal plane and greatly augmenting the precipitation at the angles in question, where the flow of water was confined to a passage several hundred feet wide made by removal of old levee in enlarging the controlling line. It practically converted the passage into a crevasse. When these cuts were made, the old levee was not disturbed nearer than 30 to 40 feet to the main line, but as the river rose and the water poured through it, it soon cut away this "stump" or short spur and reached the embankment proper.

At each of the places named a spur dike consisting of two lines of 3 by 3 inch piling was hand driven 5 feet apart, the tops tied together with stringers and cross braced as well as braced with diagonal 3 by 3 inch piling in the rear, the whole forming a stout crib which was filled with sacks of earth; these spurs were usually built about

50 feet long at an inclination of about 60 degrees to the tangent above th
allowed them to receive the water and take it gently around the e
of all of them would scour and work loose and from time to time
driven in order to maintain the structure; they all performed the se
they were constructed as no further loss of embankment was sustai
had been put in place.

Sloughs.—Under the heading of "Drainage" what produces sloughi
been described. Treatment of sloughs is simple if the principal inv
stood. It is usually the case if one occurs where an inexperienced n
that he will endeavor to restore the lost section with earth or sacks.
good, but rather tends to augment the trouble, because it makes it m
drain the slough and at the same time puts that much more weight o
mass to squash it out; squashing the sloughed mass out invariabl
some of the standing sections. He does this because he does not un
produces the slough. He does not know it is caused by too free leaka
embankment and inefficient land-side drainage.

It is a well-known fact that if any vessel encountering hydrostat
leaking, the leak can be more expeditiously stopped from the outer
side, provided, of course, the opportunities for reaching both are equ

I received my first lesson in treating sloughs by observing men a
fleet of coal barges. If a barge starts a seam leak it is impractica
the coal to get at it. It is equally impracticable to detect the leak b
the outer or water side of the barge as the inflow is too light to
hand, and then, again, as the loaded barge draws from 8 to 9 feet of
oftentimes be impossible to reach the leak by hand. But the coal-b
supply of coarse sawdust, and by means of a long handle, to which
lowers a cup of sawdust in the water in close proximity to the leak, s
just next to the barge, and as the sawdust floats out of the cup some
into the crack and becomes lodged; it very shortly gets wet and swel
is choked. Just so it is with seeping levees, but their treatment cons
loose earth in the water over the river slope. The particles of earth
the interstices, become swollen, and shortly the leak is "choked." T
sees this work in progress will immediately classify dumping loos
water as sheer nonsense and not possible of practical results, but
fact, in a short while after work has been commenced the good effects
by reduced seepage, a little later its entire stoppage, followed by no
tion of the mass to move, but rather it commences to dry out. Of co
ment does not apply to crawfish or other leaks where there is a
considerable size.

If sloughs be treated when they first occur, or, better still, befo
when their approaching occurrence is clearly indicated to the expe
the accumulation of moisture on the land slope, much annoyance a
be avoided.

Depending on the character of soil composing them, as well as
which they have been constructed, together with the opportunity for
some levees possess greater tendency to slough than others. As th
sloughs is necessarily expensive it oftentimes happens, when a numbe
proximity and the supply of labor is limited, they are only parti
wholly treated; that is, in lieu of putting a large enough blanket of
the river slope of the levee to provide against further seepage during
of the flood, only a small blanket is put on—just enough to stop th
few days. The wheeling runs are left in position and as soon as
manifests itself work is resumed until the flow is once more stoppe
a force of 15 to 20 men may be kept nearly constantly employed
slough to slough.

The following is a statement of the work done:

Bedford's to Vidalia ....
Levee completed to 54-foot (Vicksburg gauge) net grade............
Levee not having such grade..
Levees raised during flood by all methods...........................

Of the levees raised the following is the classification:

By team, 105,500 linear feet, or..
By wheelbarrows, 13,500 linear feet, or.................................
By sacks with earth backing, 51,600 linear feet, or.....................
By sacks alone, 36,550 linear feet, or..................................

Total..

the above there was 10,900 linear feet of revetment and 25,200 feet ; placed. Had the river risen a half foot more many thousand onal washboarding would have been required, and I had already ie Vicksburg mill for 100,000 feet of lumber with which to continue the river practically came to a stand and the order was counter- it is positive that the water will touch the new work it makes a piece of work if the washboards be placed first and then the raising tamped against it. But as the height of the river was so much a tion I did not wish to anticipate too far in advance and go to either rchasing the lumber or placing it where it might never be required; bor was limited and I desired to first of all get the dirt in place circumstances of dry weather, knowing full well I could put down g in any kind of weather or at night; certainly soon after the water new work and before it could be seriously damaged. This course t will be observed from the foregoing statement of the 117,000 linear s, of levee raised by teams and wheelbarrows, nearly every foot of e required planking had the water touched it, only 25,200 feet, or planked. The washboarding averages two plank high, so that, and inch boards, it requires 12,000 feet of lumber to do a mile of here was 17.39 miles raised and not washboarded it would have feet of lumber to cover it. The lumber costs $8 per thousand, or ,000 feet, to which add $25 per mile for placing it. and the total is s saved by not doing the washboarding in advance. There were large and some small, all of which were successfully treated in the d. There were something like forty places where sloughing was receiving the orthodox treatment never sloughed. There were h and other leaks, but only one assumed a dangerous appearance; e on any except the one, but it did not amount to anything serious. k, not described or included in the statement, done at two localities of special mention and description as both were extraordinary

rning of April 27, when the water was at 52 on the Vicksburg gauge, eloped under the Claggett Levee (644 R). At this place both the light loam. In the rear of the levee within 30 feet of its base there pit about 8 feet deep with almost perpendicular side next to the previous warning a 6-inch stream of water spurted out of the wall y its height; it did not merely run out and trickle down but shot from a hose. Its force was so great as to churn the water into foam hich it discharged. There are many theories as to the origin of this e will never be known unless the embankment be cut and the hole

likely a series of disconnected holes or small cavities existed under ner to burrowing animals or decayed vegetation, or probably both, ssure of water there was leakage from one to another, attended with t of wash which continued until the several holes were connected passage for the water when it burst out as described.

as immediately summoned and a semicircular wall of sacks built around it. The interior rapidly filled, and the sacks were soon the meantime a large force of teams was put to work, and a run- ed about 100 feet in the rear of the main levee and designed to be ng when completed. An opening was left in it as an outlet for the e new embankment was thought sufficiently high with proper base basin, then the opening was closed. The basin filled rapidly at first, ; at the end of two days it was found that the basin was still fill- vertop the run-around. The teams resumed work, and the embank- feet. The basin continued to fill, but as the river commenced falling her raising was not necessary. It now stands with an 8-foot crown, lopes, and a grade about 3 feet lower than the highest point reached

2115 to 2118 of winter quarters when the levee was built, due to ion, the embankment sank, and it was only after much labor and a to two or three times as much as was contained in the original cross ood. When the embankment finally stopped sinking there was a irt adjoining the land-side slope very much resembling a banquet. ving sketch shows the section originally designed and the bench of y the sinking—the dotted top is the capping that was put on with d was approaching.

ril 15 this place had shown no signs of weakness, but on that day I ut 40 feet of the back slope was getting very wet, and recommended rities that it be treated as a slough. A force was put to work dump-

ing earth on the river side, but could not work very fast on account
made necessary by the inaccessibility of dirt due to the swamp bein
covered with (there had been no rain for some weeks) seepage wat

The seepage was checked along the 40 feet, but it rapidly exten
the entire 300 feet was very wet.

Then it was observed that the top of the embankment for the
slowly subsiding. The subsidence continued for several days, whe
lengthwise with the levee, and split open just as does a ripe oran
crack was small at first, but grew from day to day until it finally re
width of 10 inches—just how far it penetrated the embankment is
front section subsided about 1.6 feet and the river section 2.3 feet.

It was plain that to hold the levee, any lateral crack which would
the vertical crack must not be allowed to occur, for if it did, ther
hydrostatic pressure on the rear section, already distressfully we
section would be valueless as a factor in resisting the pressure of

By reason of the submerged condition of the land in the rear, di
obtain and expensive to handle. To retain it in place by providing
out into the deep borrow pits, it was decided to build a crib just
of the slope to act as a retaining wall. The crib consisted of a si
inch pieces driven 6 inches from centers with a batter to the leve
stringer, and then braced on the inside with diagonal 2 by 6 inch
the levee.

When the wheeling of dirt was about to be commenced it was
was too much water over the ground to readily obtain earth, so th
be abandoned and sacks used instead. The sacks had to be filled
from the crib and were transported to it on one of our barges mo
In all, something like 25,000 heavily filled large sacks were used in
the sacking, as shown in the sketch, which occupied nearly a wee
pleted, it was believed the place was reasonably secure and no furt
unless some greater rate of subsidence than was in progress sho
precautionary measure 2,000 sacks were filled and placed on the barg
with the *Ruby* and 12 laborers, remained night and day at the crib t
in the event of an emergency until additional force could be su
never necessary, however, to place these sacks in the crib. Durin
the work, and until the river had fallen, 4-foot strips of tarpaulin
the crack to keep it dry during rainy weather.

The transportation service furnished by the United States had mu
success of holding the line during the flood. The wagon roads i
levees became so wet and boggy from seepage as to be impassabl
old levee was submerged, and it was with great difficulty that steam
ings to discharge their freights. The only places where they did
temporary platforms or barges moored to the bank, from which
moved to the levee by skiff or small flatboat. There were lengths
as 20 miles where even these kinds of landings did not exist.

Our barges, however, could be floated over the bank, and, as e
with 1,000 feet of line and a capstan, there was not much trouble t
one tree to another until the levee was reached, and then moved
that lumber or materials could be promptly delivered just whe
barges also afforded valuable service in moving loaded sacks or l
distant point to place where required where no dirt was accessible

The *Ruby* went to Cowpen Neck Levee for about three weeks and
Assistant Engineer Geddes. Being of light draft, she was extre
moving barges over the bank and along the levee; but, as stated,
available the barges were moved by hand with lines and capstan.

The *Comstock* rendered efficient service and was kept almost con
She kept in good condition, and not a minute was lost by stop
From April 14 to 23 the work required night and day running, and
with a double crew.

By the joint aid of the *Comstock* and bicycle I was able to inspec
often as every other day; kept on the go, up one day and down th
personal gratification to say that my relations with the people
pleasant. They were ever ready to be advised, and would alwa
what should be done and how to do it," and work was done as s
or two instances only did I have occasion to complain, and it turne
to comply with suggestions was through misunderstanding and no
act contrarily.

You furnished me during the flood with 225,200 feet of lumber, 17
and 54 kegs of nails. All of the latter were expended. Of the 17
34,600 remaining unused; but 144,000 hardly represents the total
know at many localities the planters used cotton-seed sacks. I
expended amount to about 175,000.

Of the 225,200 feet of lumber 151,200 feet were used. All of it was at one time distributed along the levee line, but falling river just after Biggs crevasse did not require its being placed, and it was put back on the barges.

Of the 151,200 feet put in place on the levees, 64,000 feet of it was taken up and stored after the river had receded to 49 feet at Vicksburg. All of the unexpended property and tools were moved to Kempe (657 R) levee (Station 2792) and stored on the land-side slope of the levee. The recovery of the 64,000 feet of lumber was accomplished for an average of less than $1 per thousand. Recovery of the 64,000 feet of lumber and storing it, together with storage of the other 138,000 feet in systematic piles, as well as the 34,600 sacks and all the wheelbarrows and other tools, cost, including construction of shed for wheelbarrows and warehouse for tools, $75.75.

The tools and unused sacks turned over to me by Lieutenant Hoffman, who had charge of the protection south of Vidalia, were stored in the U. S. quarter boat *Delta*. The unexpended lumber, amounting to about 120,000 feet, turned over by him to me, was stacked in piles at Station 3866+37 of the Gibsons Landing Levee (683.5 R) on the land slope.

The local authorities furnished no lumber. Many of the planters used their own tools.

I could not ascertain the exact amount of money the local authorities spent for labor and teams during the flood, but from scattering data I place the amount at about $14,000.

The following statement will be of interest, as it shows the length of levee where the water reached a stage in excess of the height of the main levee, and was held by the "capping:"

	Feet.		Feet.
0.1 foot	300	1.1 feet	200
0.2 foot	6,100	1.2 feet	600
0.3 foot	3,000	1.4 feet	700
0.4 foot	6,200	1.6 feet	100
0.5 foot	4,200	1.8 feet	300
0.6 foot	6,600	2.0 feet	200
0.7 foot	3,300	2.2 feet	100
0.8 foot	3,200	2.4 feet	200
0.9 foot	800	2.6 feet	100
1.0 foot	1,100		

The foregoing aggregates 37,300 linear feet, or 7.7 miles of levee, where the water varied from 0.1 to 2.6 feet higher than the top of the main levee, and would have overtopped it but for the "capping." At the time the Biggs crevasse occurred and stopped the rise, the river was climbing up at the rate of 0.4 foot daily, and each day brought many more miles of the capping into service. It is believed of the 31.2 miles of capping which the water did not touch, nearly all of it would have had water well against it in two days more; certainly three days' more rise would have brought it all into use.

The flood of 1897 will pass into history as the most remarkable in the experience of the Lower Tensas district, for the line was held without a break against an unprecedented flood, in spite of many adverse circumstances. It emphasizes what man can do if he but properly directs his energies.

In conclusion, I wish to pay a just tribute to the intelligence, patriotism, and untiring energy of the people of Tensas and Concordia parishes. Never before, perhaps, in their history or that of others engaged in similar occupation, have so large a body of people pursued a common end with greater unanimity of sentiment and concert of action. Personalities were laid aside and everyone, even the plantation negroes seeming imbued with the surrounding enthusiasm, worked for the common goal with tireless energy, without regard to personal comfort, irrespective of surroundings, either time, place, or weather. Their efforts were certainly full worthy of the success attained.

Very respectfully, your obedient servant,

W. J. HARDEE, *Assistant Engineer.*

Capt. GEO. MCC. DERBY,
Corps of Engineers, U. S. A.

APPENDIX 10 J.

REPORT OF MR. H. B. WATSON, SURVEYOR IN LOCAL CHARGE OF BARATARIA AND LAKE BORGNE LEVEE DISTRICTS.

NEW ORLEANS, LA., *May 1, 1897.*

SIR: I have the honor to submit the following report of surveys, construction, repairs, and high-water protection in the Lake Borgne and Barataria districts for the period from May 1, 1896 to May 1, 1897:

From May 1, 1896, to October 31, 1896, local direction of the work in was under Asst. Engineer J. Smyth, jr., since whose resignation on it has been in my charge.

BARATARIA DISTRICT.

Surveys.—Surveys in this district for the period covered by this rep cipally confined to cross sectioning old levee with a view to enlargem put the line up to a grade of 3 feet above the high water of 1893, the h when surveys were made.

All low places were surveyed from the dividing line of the parishes Plaquemines to Riceland lower line, the beginning of the Buras dis Company Canal, the extreme upper end of the district, to the Jeffers at Gouldsboro. Nothing was done in that part controlled by the Orl

New levees were projected at Ballay (1022 R), Guesnards Woods (Orange Farm (1024 R) in the Buras section.

Construction.—Entire line from the Orleans Parish line to the lowe land (State Lafourche section) was raised to a grade of 3 feet above of 1893, with the exception of the following places where objections property holders, and a small section at Magnolia, which was not com sons given below:

Live Oak (991.5 R), St. Rosalie (999 R), Myrtle Grove (1001 R), W Hache (1011 R), Warmoth (1011 R), and Socola Canal (1015 R).

All of the above were projected new levees except Warmoth, which and part enlargement.

The levee at Socola Canal was raised to a grade corresponding to th adjoining levees, but of smaller section, by the owner of the propert

At Magnolia 400 feet of the 1896–97 contract was not completed, th side of the levee to be enlarged being covered with coal. The proper gated himself to complete the work at the contract price as soon removed, and the contract was closed.

On the lower line of Magnolia 4,294 linear feet of levee was not e price bid was considered excessive.

Belle Chasse to St. Ann (984 R), and St. Ann to Concession (985 R cally completed, but owing to the existence of several pipes which of the levee in accordance with the specifications and regulations received and paid for. The contractor has had considerable trouble w using these pipes, but at this writing I understand he has agreed to re

In the upper part of the district, from Company Canal to the Orlea on account of the price asked for the work, nothing was done excep ment of 1,894 feet of Bell levee by a force of men furnished by the table associations, consisting of the city's unemployed.

A quarter boat was furnished and the men given plain board.

Total number of cubic yards of earth moved was 10,237.45 at a co including 50 per cent deterioration of outfit, supervision, etc, but not tion, which is a factor not considered in estimating cost of work. A cubic yard 10.48 cents, considerably lower than could be obtained th contract.

The arrangement of the plan was to the advantage of the United great amount of good was done by furnishing employment to a cla were willing to work, but unfortunate in not securing employment.

No work was done in the Buras section of the district.

In addition to the height of all levees being raised, five-tenths net gross, to provide shrinkage, was placed on the center of the levee w each edge of the crown, the intention being to allow the crown to dra holes forming which would hold water and keep the levee in a wet s rainy seasons.

This new departure has proved a success, and it not only causes the but seems to prevent the washing of gulleys in the edge of crown, always occurred when a flat crown was used. Of course the irregular some levees constructed by wheelbarrows shrink often affects the this arch.

Repairs.—All United States levees in this district were cleared of w where river slope was wave washed it was restored.

As a general rule the cutting of grass, weeds, etc., was done by property of the United States, drawn by a team of two mules hired fo In some instances the weeds had attained such a height and were ground line that it was impossible to use the mower, and in these cas was done by hand, as also where revetment existed, although as a slope could be mowed where the latter affected the work.

Verbal contracts were made where clearing was done by hand and w had to be restored owing to wave wash. These were usually made with some one in the vicinity, the opportunity to bid being given to several so as to secure a low bid. All this work was let at a cheap price. During the season 77,648 linear feet of levee was cleared, at a cost of $615.72; 6,891.81 cubic yards were placed in restoring wave-washed slope, at a cost of $494.54; 2,623.50 cubic yards were excavated in draining borrow pits, cost $248.90; and 12,017 linear feet of levee was resodded, cost $17.21. Total cost of repairs, $1,376.37.

LAKE BORGNE DISTRICT.

Surveys.—As in the Barataria district, surveys were confined to cross sectioning of the levee line, where low, with a view to enlargement, in order to raise the grade to a height of 3 feet above the high water of 1893.

A survey of all places where low was made with the exception of such places as had been previously surveyed and reported in last report.

At Saxonholm (974.5 L) a new levee was projected which was objected to by the property holder, who, after pressure was brought to bear by the local board, withdrew his objection, but too late for the construction of the levee to be undertaken in view of the expected high water.

At Belair (995 L) a new line was objected to by the owner, as it necessitated the removal of part of his sugar house.

From Bellevue (1005 L) downstream to Bohemia upper line (1014), that portion needing enlargement, which was surveyed, was objected to by the property holders on account of the existence of rice flumes, which were allowed by the State authorities but would have to be removed where work was done by this office.

Maps, profiles, etc., were furnished the board through its engineer and the work was done by it, the flumes being allowed to remain.

From Poverty Point (1002 L) to Harlem upper line (1003 L), 5,869 linear feet, no work was done, as objection was made. This levee was very close to the grade required but of smaller than standard section.

Construction.—From Corinne (974 L) to St. Clair (982 L) it was found when notes were platted that the amount of earth to be added was too small to warrant the enlargement, as the light character of the work raised the price to too great a figure.

From St. Clair (982 L) to Bonsejour (998 L), contracts were let for the enlargement of all levees below the 3-foot grade and of less than standard section.

Of these, the levees known as St. Clair (982 L), 9,640 linear feet; Mon Plaisir (983 L), 4,916 linear feet, and Greenwood (990 L), 3,472 linear feet were not worked on, as the river rose and covered the batture before the contractor, who had a number of other contracts farther down, could get a force on them.

Woodlawn (992.5 L) was completed with the exception of 2,000 feet, the work being stopped by the water, but according to contract could not be received and paid for until entirely finished, and the contractor will have to sustain all damage by wave-wash during the present high water.

Some work was done at Harlem (1005 L); 400 feet of enlargement in that part called St. Sophie to Harlem (1004 L) was left incomplete owing to the rise of the river.

Repairs.—All United States levees were cleared of weeds, etc., and slope restored where wave-washed. Methods and general conditions were the same as in the Barataria district. Seventy-eight thousand seven hundred and four linear feet of levee was cleared at a cost of $574.25; 2,734.06 cubic yards of earth was placed in restoring wave-washed slope; 2,677.30 cubic yards of earth was excavated in draining borrow pits. Total cost of repairs, $1,007.15.

High-water protection.—The present high water has proved a record breaker. After the first rise under the usual conditions it became obvious that trouble would be experienced.

All work under construction previous to the rise was completed, with the exception of Woodlawn, work on which was interrupted March 16, and St. Sophie to Harlem on March 1.

After the water reached the danger line it became evident that an exceptionally high stage would be reached, and a warning was given out from this office to the local boards and all interested. Although some were somewhat skeptical as to the extreme height predicted, all concerned in the districts under my local charge went to work with a will, and their efforts directed at the right time tended greatly to cause the result obtained, viz, the maintenance of the entire stretch. Owing to the appropriation being small it was found that the only assistance which could be given by the United States would be for the use of sufficient barges for the transportation of necessary lumber, tools, etc., from point to point and the services of a tug for each 60 miles of river. On the lower coast it was decided that where the railways paralleled the river bank material could be transported more quickly by that method.

From the line of Orleans and Plaquemines parishes to Belle Chasse sugarhouse the stretch could only be reached by river; also from Belair (995 L), the terminus of the

New Orleans and Southern Railroad, to Bohemia (1015 L), the low Borgne district.

The request of the Lafourche board that the United States ta part above Belle Chasse sugarhouse, being 28,352 linear feet, or 5. and in that event they would transport all material by rail to the tion and provide tools, etc., not requiring any assistance in the s towing, was favorably received, and but one barge was station referred to.

From Belair to Bohemia, 20 miles, it was found necessary to fully equipped with tools, lumber, etc., the tools and accessories United States and lumber by the local board for the first shi an additional barge was furnished, the river conditions making necessary.

The tug *Day Dream* was chartered and located with headquart The towing of all barges and transportation of men and materials was done by her.

After additional funds became available it was found that mat of lumber, sacks, and nails could be furnished, and as the boards erished condition to a certain extent by this time, the assistance Lake Borgne board was furnished with 135,315 feet of lumber of re and 14,000 sacks. The lumber was loaded on United States barg and towed to points where needed by chartered tugs, except 30,023 cars of the New Orleans and Southern Railroad for use on the s this line. The sacks were shipped by local packets and distribute thought to be necessary at different points over the entire line.

Thirty-four thousand six hundred and eighty-four feet of lumber, 4,000 sacks were sent to the barge stationed at Fort St. Leon in after and maintained by the United States; transportation by G and chartered tug. Some of this will be returned to the Govern all danger is over, as a large portion used temporarily to protect a can be taken up and reloaded on the barge.

The State Buras district, the lower part of the Barataria distr with 168,033 feet of lumber and 8,000 sacks. These were transp Orleans, Fort Jackson and Grand Isle Railroad free of charge, the o portation being the amount for ferriage to the depot of the railro opposite side of the river. The superintendent of the ferry com ously granted a half rate on all levee materials. No material was part of the Barataria district from Company Canal to the Orleans

CONDITIONS AND EFFECT TO DATE.

BARATARIA DISTRICT.

The principal points in this district where trouble was experi new lines had been projected last season and not built, owing property holders.

At Live Oak (991.5 R), one of these points, the local board enlar after objections had been made to a new line, knowing it to be un great strain, but when the water rose a few feet on the base, it wa forated with crawfish holes. In fact, the ditch on the land side wa from these leaks before the river covered the berme of the levee, digging of a large ditch at the toe of the slope and the refilling of s to cut off the holes. This was partially successful, but when the reached, it was found necessary to build boxings in a great many

At St. Rosalie, another point where a new line was objected t topped the line to such an extent as to necessitate a rise of a foo This levee proved sound with the exception of one or two places was exceedingly small.

A great fight was made here. At one time it looked an impossi line. The only criticism to be made of the work done was the ru which sacks were used. Where the capping could have been done of work at other points, by placing planks edgeways and filling which was easily obtainable, the entire crown was raised with sac

At Myrtle Grove (1001 R) the same conditions prevailed. Th dangerous place in the district, as, in the event of a break, it would impossible to have done anything toward closing it, the levee be the bank.

Herculean efforts were necessary here, as the water rose fully 1.5 of the levee. As many men as could be conveniently employed an interfering with each other were kept continuously at work for se great amount of work was done at night. The entire stretch was feet long. Everything was made absolutely safe eventually, but a reat many sacks were used needlessly. At one time it was necessary method, as there was great danger, and sacks were the proper thing, ash had been arrested and the levee made practically safe, the entire rown were covered with sacks.

nal (1015 R) much work was necessary in that part too near the river and which the proprietor of the locks had obligated himself to main- t piling between the gates gave way somewhat, and it looked as if the d blow out if nothing was done, necessitating the closing of the locks d the maintenance of a half stage of water between the gates in ute the strain.

at Belle Chasse looked after by the United States was all levee built cept 2,000 feet built by the State and recently enlarged under the le Chasse contract and of standard section and height.

and lower ends of the stretch the work of protection was mainly con- ng against wave-wash. As so much had been recently enlarged on nd had not become turfed, more damage was expected than what ed. That part which gave the most trouble was in the vicinity of old n the first Belle Chasse Levee built. About 1,000 feet of it was found nbed with crawfish leaks, which poured a large quantity of water se of the levee. Numerous boxings were built and filled with earth, larger ones, and when good drainage was established, it became drying of the slope and decrease in the flow of water that the work ve.

er had been against this levee for some time numerous soft places me instances causing the land slope to puff up and become spongy. eeds were cleared from the levee, and where these places were found rallel to each other were cut at requisite distances, and in a great was found that nothing further was necessary, but at the worst ng the river slope had to be resorted to. A box was made with inch ape of sheet piling around a framework about 3 feet up from the toe d loose earth piled in to the height of the water. In all but one complished the desired result by causing the land side to dry out and At one point where the levee puffed up and became very soft and nger of sloughing out, a mud box had to be built, braced to the vater cut off from the river slope.

water is at present very near its highest mark, and continual vigi- ecessary, everything looks secure, and the work done is confined ng of weeds and drainage.

—In the Buras section of this district the hardest fight of all was e water came to the top of or overtopped nearly the entire line, the was of poor section. Considering the small amount of money and cal board had available, a splendid fight was made, and although ral breaks, two of which assumed quite a size, they were closed and ntact. A great deal of credit is due to the members of the board s generally along the line for the work done. Very nearly all the re and some sacks were furnished by this office, and to this assist- ttributed the success attained. All the flumes in the district gave e time, and the majority of them were closed entirely. In two large crevasses were occasioned by the caving in of flumes. These greatest menace to the levees in this section, and a movement is on m ordered out by act of the legislature at its next session.

he two worst places large eels were taken out of the middle of the wall of the flume, which shows a new factor among the levee ough it is probable that holes are originally made by crawfish, who e woodwork of the flume is reached and then dig out large places nber collect. When the hole leading from the river to this space tly large, the eels probably work their way in, in search of either place.

vasse of any size occurred at Melrose (1023 R), and before it was a width of 65 feet, with an average depth of 7 feet, except at the 2 feet was reached, owing to the existence of an old flume ditch on his break gave considerable trouble, and it was several days before After hearing of the trouble early in the morning, I went to the train with Superintendent Landry, of the Grand Isle Railroad, and, thority from this office, ordered the tug *Day Dream* to the break with ber.

, which had been loaded the day before, were taken down by special was begun, but progress was slow until the arrival of the barge n the material could be placed right at the break and the top of the workshop by those preparing the lumber. On the second morning ccurred about 1,000 feet lower down, which reached 65 feet in width,

but with only 4 feet of water going through the breach. This necessitated a divis
of the force and delayed the closing of the first break.

Although the cribbing gave way at each place several times, the water was eff
ually stopped and a mud box built. The one great trouble was the absence of li
to permit of working at night. Several times much of the work done in the
would wash away at night. It having been decided to place powerful lig
aboard each barge sent out during the next high water, this trouble will be obvia
The assistance rendered by the United States in furnishing materials and the us
the barge stationed near the breaks was probably responsible for the good w
done, as I do not think it would have been possible to have accomplished the res
floating lumber from the railway against the current to the levee, and working
crown not over 3 feet wide, even if the board had been able to provide material.

Providence appears to have been with the people of this section, as a contin
rainy spell or one big storm such as occurs periodically, the Gulf being so n
would have caused portions of the levee to wash away all along the line. It is
be sincerely hoped the present favorable weather conditions will continue.

LAKE BORGNE.

The levees in this district being all of standard height and section, with
exceptions, most of the trouble experienced was caused by leaks and sloughs in
work.

As is always the case, the leaks occurred all along the line, and were taken in t
as each developed symptoms of becoming dangerous—boxed or worked on in wh
ever manner was considered most advisable—and in but few instances was there
serious trouble. There was a very serious leak at Pecan Grove (974.5 L), the wa
boiling up on the inside from a large hole, through which a fish came. A large
was built and this made secure. Sloughs occurred at Slaughterhouse (970 L) and
along the stretch of levee at Pointe a la Hache recently enlarged by the board.
the Slaughterhouse a great deal of excitement was occasioned by the sloughing,
the citizens took it in hand and did considerable work, for which they are to be co
mended; but, from my observation, I do not think that there was any occasion for
excitement, as at no time did it appear to me there was absolute danger of the le
going at any moment. Of course it is advisable when these sloughs occur to rep
them immediately, but in the usual order of things. The sloughing on the Pointe
Hache front was much worse, as it was not protected by revetment, and sloug
both front and back. This was taken systematically and the whole strengthen
as any ordinary protection work. One small place in front of Crowley's, at
Slaughterhouse, might have become dangerous suddenly, as the original old lev
which had been enlarged, was only one foot higher than the water of 1893, and
the water at the time was 1.5 feet higher, there was only new earth above the wa
line.

A great deal of work was done and the board members and commissioners a
inspectors deserve great credit.

Trouble was experienced here also from flumes, which are allowed in the lev
From Savoies (1005 L) to Bohemia (1015 L) thirteen in all blew out and were clos
Nearly all who owned flumes that gave trouble are assisting to circulate a petiti
to the next legislature requesting the passage of a law making them unlawful, a
it is pretty safe to say that they will all be out by the next high water. Eels we
also found in some of these flumes.

The service of the tug in that part not covered by rail was of inestimable valu
and several times what might have been bad breaks were averted by the prom
arrival of material. The lumber and sacks donated were of great service, but it
acknowledged by all that to the presence and service of the tug can be attribut
the success of maintaining the line.

In the Grand Prairie country, from the lower extremity of the Lake Borgne di
trict downstream, the levees are built by each individual owner and are generall
small affairs. At an early date the water topped them and several breaks occurre
Assistance in the shape of lumber, with which to close these crevasses, was requeste
by the residents thereof, through a committee, but it was not thought advisable
assent to the request, as the relief would only be temporary, it being evident tha
before the water reached its highest stage the levees would give way in a doze
places, the only salvation being to raise the entire line, which was out of the que
tion. At present the water is running over the levee almost everywhere, and th
entire country is one vast lake, except where side and back levees have been buil
and the front maintained, which has been done in several places.

Although the poorer people will suffer much hardship while the water is up, it i
thought that a rice crop after the river falls sufficiently will be a possibility, an
as the land will be in such shape as to save considerable expense in flooding, an
vastly improved by the deposit of silt, there seems to be a probability of a speedy
return to a prosperous condition.

To offer to pay a part of the expense of restoring the line, provided the citizen ee district under State law, which was made upon the request for is line, and agreed upon, will give this country what it has never fective levee.

REMARKS.

ble at this writing to give accurate data in all instances of the effect er, as the river is well up on the levees in both districts.

obvious, and that is that the deposit has been greater than ever ure having been raised to within a foot of the flood level at many e line. Where the batture has grown up in willows or other trees underbrush, the outer edge of the bank only has been raised; but and the current has had full sway, the deposit extends all the way pe, with a gradual incline from the edge of the bank to the levee. has not been the case in all instances, as local causes, such as eddies, litions.

nclined to believe for some time that an open batture was a correct wer river, and what I have observed so far strengthens that belief. is one high water has in some instances raised the batture where pits awfish existed, to within 2 or 3 feet of the flood level, is a point in a.

ne from Belle Chasse down does not exceed, on an average, 100 feet ver bank, I think the cost of clearing the batture would be small. e of levee could be temporarily protected with the willows cut from d after one or two high-water seasons I am of the opinion that we lid bank extending from the present levee to the edge of the bank, t the latter within 1 foot of the high-water mark. There would be crawfish would breed, and their burrowing would necessarily be de.

to this plan is the uncertainty of the high water, and if it were nec- he batture for two or three seasons before the river reached a stage give the desired result, in might raise the cost to such an extent as racticable.

of the water and the cost of repairs to slope of levee and cutting out s, etc., is definitely known, an estimate could be made of the prob- intenance of the system for twenty years, and a comparison made, me to be practically nothing after the result sought by the above .

nuch-mooted question of levee protection in the shape of revetment, d, no concise report on this subject can be made until the actual unprotected levees is determined, after the fall of the river.

as maintained very nearly its highest stage on the lower river until o comparison of flood heights with those of 1893 has been made. facts relative to grades will be shown when this is done, and recom- future work can then be made.

ectfully, your obedient servant,

H. B. WATSON, *Surveyor.*

cC. DERBY,
ps of Engineers, U. S. A.

APPENDIX 10 K.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., July 23, 1896.

of proposals received in response to advertisement dated June 11, 1896, by Capt. George McC. Derby, Corps of Engineers, for levee work in fourth ing Mississippi River.

[Prices bid are per cubic yard.]

ame and address of bidder.	Brulard to Belle Chasse Levee.		Belle Chasse to St. Ann Levee.	St. Ann to Concession Levee.
	Section 1.	Section 2.		
	Cents.	*Cents.*	*Cents.*	*Cents.*
& Son, New Orleans, La	15.50	15.50	14.50	13.25
St. Gabriel, La	15	15.50	....	....
ple, New Orleans, La	14	14	15	14.50
ll & Co., New Orleans, La	13.85	15.50	19	13
& Co., New Orleans, La	20	20	20	20
., New Orleans, La	[a] 13.25	[a] 13.25	[a] 13	[a] 13
mara & Co., New Orleans, La	13	13.50	15	14.50

No. 1.—*Abstract of proposals received in response to advertisement dated June 11, etc.*—Continued.

No.	Name and address of bidder.	Concord Levee.	Cedar Grove Levee.	Oakville Levee.	Jesuits Bend Levee.	Dob Lev
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cen*
1	J. A. Andrews & Son, New Orleans, La	13.25	14.50	14.50	14.50	1
3	Barbour & Ruple, New Orleans, La	14	14	14	15	1
4	A. Brandt, jr., Myrtlegrove, La					1
5	C. D. Leeper, Baton Rouge, La		14.25	14.25	14.25	1
7	Chas. O'Donnell & Co., New Orleans, La	14	14	18	17.25	1
9	G. W. McFall & Co., New Orleans, La	20				
11	H. B. Turcan, Jesuits Bend, La				13.99	1
12	Thos. Egan, jr., New Orleans, La	*a* 13	12.50	12.50	12	1
16	Pat. H. Lyons, Luling, La					1
17	Joseph Hingle, jr., Homeplace, La		*b* 11	*b* 11	*b* 11	*b* 1
18	Robt. McNamara & Co., New Orleans, La	15	14	14	13	1
20	John Cleary, New Orleans, La					1

No.	Name and address of bidder.	Tocoora Levee.	St. Rosalie Levee.		
			Section 1.	Section 2.	Sectic
		Cents.	*Cents.*	*Cents.*	*Cen*
1	J. A. Andrews & Son, New Orleans, La	13.25	13.25	13.25	1
3	Barbour and Ruple, New Orleans, La	15	11.95	11.95	1
5	C. D. Leeper, Baton Rouge, La	14.25	14.25	14.25	1
7	Charles O'Donnell & Co., New Orleans, La	14.25	13.25	13.25	1
8	Gray & Ryan, Westwego, La		10.72	10.72	1
10	Charles G. Daunoy, St. Sophie, La		11.95	11.95	1
11	H. B. Turcan, Jesuits Bend, La	13.99		12.49	
12	Thomas Egan, jr., New Orleans, La	12	14	14	1
16	Patrick H. Lyons, Luling, La		12.99	12.99	1
17	Jos. Hingle, jr., Homeplace, La	*b* 11	*b* 11	*b* 11	*b* 1
18	Robert McNamara & Co., New Orleans, La	13	14	14	1

No.	Name and address of bidder.	Ironton Levee.	Woodpark Levee.	Deer Range Levee.	Pot Cele Lev
		Cents.	*Cents.*	*Cents.*	*Cent*
1	J. A. Andrews & Son, New Orleans, La	13.25	13.75	14.50	1
3	Barbour & Ruple, New Orleans, La	16	14	16	1
6	Simon Leopold, Phoenix, La		11.75		
12	Thomas Egan, jr., New Orleans, La	12	12		
14	Victor Adema, Myrtlegrove, La		12.48		
15	Robert Brandt, Myrtlegrove, La		12		
17	Joseph Hingle, jr., Homeplace, La	*b* 11.30	*b* 11.30	*b* 11.30	*b* 1
18	Robert McNamara & Co., New Orleans, La	14			
19	Philip Douglas, New Orleans, La	13.50	12.50	13.50	1
20	John Cleary, New Orleans, La		11		

No.	Name and address of bidder.	Woodland Levee.	Magnolia Levee.	Friends Store Levee.	Barthele Leve
		Cents.	*Cents.*	*Cents.*	*Cents*
1	J. A. Andrews & Son, New Orleans, La	14.50	14.50	14.50	1
3	Barbour & Ruple, New Orleans, La	14.50	20	15	1
13	Victor Treadaway, City Price, La			15	1
17	Joseph Hingle, jr., Homeplace, La	*b* 11.30	*b* 11.30	*b* 11.30	*b* 1
19	Philip Douglas, New Orleans, La	13.50	15	12.50	1

a Bid No. 12 accepted for whole line from Bruslard to Belle Chasse Levee to Concord Levee.
b Bid No. 17 accepted for whole line from Cedargrove Levee to Barthelemy Levee.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., August 18, 1896.

No. 2.—*Abstract of proposals received in response to advertisement dated August 3, 1896, opened this day by Capt. George McC. Derby, Corps of Engineers, for levee work in fourth district, improving Mississippi River.*

[Prices bid are per cubic yard.]

No.	Name and address of bidder.	Riverton Levee.	Burnside Levee.	Union Levee.	Tippecanoe Levee.	Whitehall Levee.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Hearin & O'Connor, Anchor, La	*a* 8.74	*a* 8.35	*a* 8.73	*a* 8.40	*a* 8.45
2	Gray & Ryan, Westwego, La	9.40	9.40	9.40	9.40	8.40
3	Charles O'Donnell, King, La	11.50	11.50	11.50	11.50	11.50
4	Deely & Burns, Sellers, La	10.25	8.35	8.35	8.35	8.35
5	C. D. Leeper, Baton Rouge, La	9.91	9.91	9.91	9.91	9.91
6	Hayes Bros., Baton Rouge, La	10.50	10.50	10	10	10
7	J. Curtis, Lagan, La	12.75	12.75	11.75	12.75	12.75
8	V. Adema, Myrtlegrove, La	11.98	11.98	11.98	11.98	11.98
9	G. W. McFall & Co., New Orleans, La	18	18	18	18	18
10	Donovan & Daley, Killona, La	9⅛	9⅛	9⅛	9⅛	9⅛

a Accepted.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., August 19, 1896.

No. 3.—*Abstract of proposals received in response to advertisement dated August 3, 1896, opened this day by Capt. George McC. Derby, Corps of Engineers, for levee work in fourth district, improving Mississippi River.*

[Prices bid are per cubic yard.]

No.	Name and address of bidder.	Lillie Levee.	Sauve Levee.
		Cents.	*Cents.*
1	John Cleary, New Orleans, La	....	12.50
2	C. D. Leeper, Baton Rouge, La	*a* 9.25	11.91
3	Gray & Ryan, Westwego, La	11.40	11.40
4	G. W. McFall & Co., New Orleans, La	17	17
5	Barbour & Ruple, New Orleans, La	13.50	13.50
6	V. Adema, Myrtlegrove, La	11.96	11.96
7	J. Curtis, Lagan, La	14.95	13.50
8	Chas. O'Donnell & Co., King, La	12.50	12.50
9	Deely & Burns, Sellers, La	10.35	*a* 9

a Accepted.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., September 22, 1896.

No. 4.—*Abstract of proposals received in response to advertisement dated September 5, 1896, opened this day by Capt. George McC. Derby, Corps of Engineers, for levee work in fourth district, improving Mississippi River.*

[Prices bid are per cubic yard.]

No.	Name and address of bidder.	Rifle Point Levee.			
		Section 1.	Section 2.	Section 3.	Section 4.
		Cents.	*Cents.*	*Cents.*	*Cents.*
1	John C. Hodge, Darrow, La	9.90	9.90	9.90	9.90
2	F. M. McLaughlin, Waterproof, La	9.90	9.90	9.90	9.90
3	John McTighe, Memphis, Tenn	12.50	12.50	12.50	12.50
4	Manning & Gibson, Greenville, Miss	*a* 8.70	*a* 9	*a* 9	*a* 9

a Accepted.

UNITED STATES ENGINEER C
New Orleans, La., Septemb

No. 5.—*Abstract of proposals received in response to advertisement dated 1896, opened this day by Capt. George McC. Derby, Corps of Engineers, in fourth district, improving Mississippi River.*

[Prices bid are per cubic yard.]

No.	Name and address of bidder.	Cottage Home Lev	
		Section 1.	Sectio
		Cents.	*Cen*
1	Chas. O'Donnell, New Orleans, La.	11.75	1
5	Garbish & O'Neil, Point Pleasant, La.	11	1
7	C. D. Leeper, Baton Rouge, La	*a* 10.49	*a* 1
8	Manning & Gibson, Greenville, Miss.	12	1

a Accepted.

UNITED STATES ENGINEER
New Orleans, La., Septem

No. 6.—*Abstract of proposals received in response to advertisement dated Se opened this day by Capt. George McC. Derby, Corps of Engineers, fo fourth district, improving Mississippi River.*

[Prices bid are per cubic yard.]

No.	Name and address of bidder.	Evergreen Lev		
		Section 1.	Section 2.	Secti
		Cents.	*Cents.*	*Cen*
1	F. P. Hanick, St. Gabriel, La.	18	....	.....
2	C. D. Leeper, Baton Rouge, La.	9.1	9.1	
3	Charles O'Donnell, New Orleans, La	10	10	
4	Batt O'Brien, Point Pleasant, La.	*a* 9	*a* 9	*a*
5	Garbish & O'Neil, Point Pleasant, La.	9	9.5	
6	F. M. McLaughlin, Waterproof, La.	10	10	
7	B. Killeen, Arbroth, La.	14.25	14.25	

No.	Name and address of bidder.	Evergreen Lev		
		Section 5.	Section 6.	Secti
		Cents.	*Cents.*	*Ce*
2	C. D. Leeper, Baton Rouge, La.	10.49	10.49	
3	Chas. O'Donnell, New Orleans, La.	11	11	
4	Batt O'Brien, Point Pleasant, La	*a* 9	*a* 9	
5	Garbish & O'Neil, Point Pleasant, La	10.70	10.70	
6	F. M. McLaughlin, Waterproof, La	10	10	
7	B. Killeen, Arbroth, La.	14.25	14.25	

a Accepted.

UNITED STATES ENGINEE
New Orleans, La., Sept

No. 7.—*Abstract of proposals received in response to advertisement dated opened this day by Capt. George McC. Derby, Corps of Engineers, fourth district, improving Mississippi River.*

[Prices bid are per cubic yard.]

No.	Name and address of bidder.	Winter Quarters Lev				
		Section 1.	Section 2.	Section 3.	Section 4.	Sect 5.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cen*
1	Timothy Sullivan, Memphis, Tenn.	16.95	16.95	16.95	16.95	16.
2	C. D. Leeper, Baton Rouge, La.	19.99	19.99	19.99	19.99	19.
3	Batt O'Brien, Point Pleasant, La.	35	35	35	35	35
4	Charles O'Donnell, New Orleans, La.	*a* 14.50	*a* 15.50	*a* 17	*a* 15	*a* 18
5	F. M. McLaughlin, Waterproof, La.	19	19	19	19	19

a Accepted.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., September 26, 1896.

No. 8.—*Abstract of proposals received in response to advertisement dated September 5, 1896, opened this day by Capt. George McC. Derby, Corps of Engineers, for levee work in fourth district, improving Mississippi River.*

[Prices bid are per cubic yard.]

No.	Name and address of bidder.	Ashley to Fairview Levee.							
		Section 1.	Section 2.	Section 3.	Section 4.	Section 5.	Section 6.	Section 7.	Section 8.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	D. P. Lyles, Planchette, La	*a* 10	*a* 13	*a* 14.50	*a* 14.50	*a* 14.50	*a* 11	*a* 10	*a* 9.24
2	John C. Hodge, Darrow, La	21	21	21	21	21	21	11	10
3	F. M. McLaughlin, Waterproof, La	14.75	14.75	14.75	14.75	14.75	14.75	14.75	14.75
4	Lewis M. Dalgarn, Natchez, Miss	23	23	23	23	23	23	23	23

a Accepted.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., November 13, 1896.

No. 9.—*Abstract of proposals received in response to advertisement dated October 26, 1896, opened this day by Capt. George McC. Derby, Corps of Engineers, for levee work in fourth district, improving Mississippi River.*

[Prices bid are per cubic yard.]

No.	Name and address of bidder.	St. Clair Levee.	Mon Plaisir Levee.	Greenwood Levee.	Bertrandville Levee.	Woodlawn Levee.	Belair Levee.	Fairview Levee.	Bonsejour Levee.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Barbour & Ruple, New Orleans, La	14.20	14.20	14.20	14.20	14.20	14.20	14.20	14.20
3	D. D. Daunoy, Dalcour, La	16	16	16	14.50	14.50	....	....	....
4	John F. Meyer, English Turn, La	13.50	13.50	....	....	....	....	....	....
7	Chas. G. Daunoy, St. Sophie, La	*a* 11.40	*a* 11.40	*a* 11.40	*a* 12.00	*a* 11.40	*a* 11.40	*a* 11.40	*a* 13
8	J. A. Andrews & Son, New Orleans, La	....	....	....	....	16	16	16	16

a Accepted.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., November 23, 1896.

No. 10.—*Abstract of proposals received in response to advertisement dated November 12, 1896, opened this day by Capt. George McC. Derby, Corps of Engineers, for levee work in fourth district, improving Mississippi River.*

[Prices bid are per cubic yard.]

No.	Name and address of bidder.	Lafourche district.					
		Sections 7, 8, 9, and 10.	Sections 11, 12, and 13.	Sections 21, 22, and 23.	Sections 24, 25, and 26.	Sections 30, 31, 32, and 33.	Sections 36, 37, 38, and 39.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Frank Burke, Orange, Tex	9.75	9.75	11.50	11.50	12	12
2	C. D. Leeper, St. Joseph, La	14.50	15	15.50	13.50	14.50	15
3	Donovan & Daley, Waggaman, La	*a* 9⅛	*a* 9⅛	*a* 9⅛	*a* 9⅛	*a* 9⅛	*a* 9⅛
4	J. A. Andrews & Son, New Orleans, La	12	12	13	13	13	13
5	F. M. McLaughlin, Waterproof, La	11.50	11.50	11.50	11.50	11.50	11.50
6	Barbour & Ruple, New Orleans, La	11.30	11.65	12.45	12.45	....	....
7	Jasper Henline, Convent, La	....	....	....	....	....	11

a Accepted.

UNITED STATES ENGINEER O
New Orleans, La., Novemb

No. 11.—*Abstract of proposals received in response to advertisement dated*
1896, opened this day by Capt. George McC. Derby, Corps of Engineers, f
in fourth district, improving Mississippi River.

[Prices bid are per cubic yard.]

No.	Name and address of bidder.	St. Elmo Levee.	Morgan Levee.	Edgewa Levee
		Cents.	*Cents.*	*Cent*
1	J. A. Andrews & Son, New Orleans, La	....	*a* 10	11
2	John Cleary, New Orleans, La	....	....	....
3	C. D. Leeper, St. Joseph, La	*a* 12. 50	15. 50	15.
4	B. J. Kuhlman, St. Rose, La	....	11. 50	14.
5	Barbour & Ruple, New Orleans, La	....	10. 94	*a* 10.

a Accepted.

UNITED STATES ENGINEER O
New Orleans, La., Novemb

No. 12.—*Abstract of proposals received in response to advertisement dated*
1896, opened this day by Capt. George McC. Derby, Corps of Engineers,
in fourth district, improving Mississippi River.

[Prices bid are per cubic yard.]

No.	Name and address of bidder.	Pointe Coupee Lev	
		Section 1.	Section
		Cents.	*Cents.*
1	Donovan & Daley, Waggaman, La	....	....
2	F. P. Hanick, St. Gabriel, La	21	....
3	F. M. McLaughlin, Waterproof, La	*a* 13. 50	*a*

a Accepted.

UNITED STATES ENGINEER O
New Orleans, La., Decemb

No. 13.—*Abstract of proposals received in response to advertisement dated*
1896, opened this day by Capt. George McC. Derby, Corps of Engineers, f
improving harbors at Natchez and Vidalia, Mississippi and Louisiana.

[Prices bid are per cubic yard.]

No.	Name and address of bidder.	Cowpen Nec	
		Sections 1 and 2.	Section 3 and
		Cents.	*Cents.*
1	E. B. Helgason, Point Pleasant, La	11. 95	13.
2	Clark & Pringle, Raccourci, La	*a* 12	*a* 12
3	James R. Marlow, Natchez, Miss	13	14.

a Accepted.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., February 11, 1897.

No. 14.—*Abstract of proposals received in response to advertisement dated February 1, 1897, opened this day by Capt. George McC. Derby, Corps of Engineers, for levee work in fourth district, improving Mississippi River.*

[Prices bid are per cubic yard.]

No.	Name and address of bidder.	Gomez Levee.	
		Section 1.	Section 2.
		Cents.	*Cents.*
1	V. Adema, Nero, La	15.50	15.50
2	Barbour & Ruple, Donaldsonville, La	10.73	10.73
3	Jordan Bros., Alexandria, La	*a* 8.15	9.45
4	Geo. Byrne, Plaquemine, La	9.45	*a* 7.92
5	G. M. D. Grigsby, New Orleans, La	11.75	11.75
6	F. Burke, Algiers, La	10.90	10.90
7	E. B. Helgason, Point Pleasant, La	8.94	8.94
8	Geo. Y. Andrews, New Texas, La	16	16

a Accepted.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., September 26, 1896.

Abstract of proposals received in response to advertisement dated August 28, 1896, opened this day by Capt. George McC. Derby, Corps of Engineers, for furnishing 5,000 tons of rock for improving harbor at New Orleans, La.

No.	Name and address of bidder.	Per ton.	Remarks.
1	Chas. G. Smith & Son, Washington, D. C	$3.38	
2	David V. Howell, New York, N. Y	3.38	
3	John Barrett, Cincinnati, Ohio	2.40	
4	William J. Bishop, Lithonia, Ga	2.64	
5	A. P. Birch, Blount Springs, Ala	2.21	Accepted for 4,000 tons.
6	Chas. Clark & Co., Galveston, Tex	2.90	
7	Allan A. Goodwin, Zimmerman, La	4.00	
8	D. & J. Tranchina, New Orleans, La	1.72	Accepted for 1,000 tons.
9	Lewis M. Dalgarn, Natchez, Miss	2.45	
10	A. A. Goodwin, Zimmerman, La	3.00	
11	Leo. Gunning, Redwood, Miss	3.35	
12	L. J. Mestier & Co., New Orleans, La	2.40	For 3,000 tons only.
13	W. R. Harteck, New Orleans, La	2.65	
14	The Georgia Quincy Granite Co., Macon, Ga	2.60	
15	Frederick Hartweg, Cincinnati, Ohio	2.95	
16	Silas C. Doby, Lithonia, Ga	2.98	
17	J. A. Andrews & Son, New Orleans, La	2.71	
18	Robt. J. Connelly, New Orleans, La	3.35	
19	G. H. Ellerbe, New Orleans, La	2.51	

INDEX.

[The references in Roman are to part (or volume), and those in Arabic to page.]

A.

cts. *See* Laws.
cushnet River, Mass. *See* New Bedford Harbor.
gate Bay, Minn., improvement of harbor at ... I, 386; III, 2588
hnapee Harbor, Wis.:
  Improvement of ... I, 398; IV, 2672
  Occupancy of south pier ... VI, 3984
  Survey of ... I, 408; IV, 2755
id to injured employees engaged on public works, necessity of legislation for ... I, 25
ilsa (steamship), removal of wreck of ... I, 114, 1039
labama Great Northwestern Railway Company, bridge of ... I, 530
labama River, Ala.:
  Bridge near Montgomery, construction of ... I, 530
  Improvement of ... I, 260; II, 1633
lameda, Cal., alteration of bridge between Oakland and ... I, 535
lbemarle and Chesapeake Canal, N. C., improvement of waterway via. I, 195; II, 1374
lbemarle Sound, N. C., improvement of waterway to Norfolk Harbor, Va ... I, 195; II, 1374
lburgh Point, Vt., construction of bridge across Missisquoi Bay at ... I, 535
lequa Creek, Fla., construction of bridge across, near Portland ... I, 534
lexandria Bay, N. Y., examination of harbor at ... I, 482; IV, 3312
llegheny and Westmoreland Bridge Company, bridge of ... I, 533
llegheny River, Pa.:
  Construction of locks and dams in ... I, 363; III, 2428
  Improvement of ... I, 362; III, 2424
llouez Bay, Wis., modification of harbor lines in ... I, 23; III, 2647
lloway Creek, N. J., improvement of ... I, 150; II, 1220
lmora (bark), removal of wreck of, from Man of War Harbor, Key West, Fla ... I, 251; II, 1566
lpena Harbor, Mich., improvement of ... I, 441; IV, 3011
lsea River, Oreg., improvement of ... I, 499; IV, 3393
ltamaha River, Ga., improvement of ... I, 230; II, 1513
lvena (steamer), removal of wreck of ... I, 114, 1040
lviso Creek, Cal., survey of ... I, 488; IV, 3343
mite River, La., improvement of ... I, 280; II, 1756
ndura Creek, Va. *See* Nandua Creek.
nna Augusta (schooner), removal of wreck of ... I, 138, 1157
nnapolis Harbor, Md., survey of ... I, 175; II, 1309
nn, Cape, Mass., construction of harbor of refuge at Sandy Bay ... I, 49, 832
nto (bark), removal of wreck of, from Man of War Harbor, Key West, Fla ... I, 251; II, 1566
Apalachicola, Fla., survey of approaches to ... I, 262; II, 1655
Apalachicola Bay, Fla.:
  Improvement of ... I, 254; II, 1605
  Survey of, including approaches to Apalachicola ... I, 262; II, 1655
Apalachicola River, Fla., improvement of, including the Cut-off ... I, 254; II, 1609
Appleton, Wis., construction of bridge across Fox River Canal at ... I, 532
Appomattox River, Va., improvement of ... I, 193; II, 1369
Appoquinimink River, Del., improvement of ... I, 158; II, 1261
Aqueduct Bridge, Potomac River, at Washington, D. C., repair of ... I, 536; VI, 3987
Aquia Creek, Va., improvement of ... I, 179; II, 1324
Aransas Harbor Terminal Railway Company, bridge of ... I, 530

Beaumont, Tex., construction of bridge across Neches River at............ I, 531
Belfast Harbor, Me., improvement of............ I, 32, 781
Bell, Alice (schooner), removal of wreck of............ I, 153; II, 1227
Bellamy River, N. H., improvement of............ I, 40, 794
Belle River, Mich., improvement of............ I, 448; IV, 3025
Bellingham Bay, Wash., survey of............ I, 523; IV, 3478
Benton Harbor, Mich. *See* St. Joseph Harbor.
Beverly, Mass., construction of bridge between Salem and............ I, 532
Bibb County, Ala., construction of bridge across Cahaba River, in............ I, 530
Big Assawaman Bay, Del., improvement of waterway via............ I, 162; II, 1270
Big Sandy River, W. Va. and Ky.:
  Improvement of............ I, 377; III, 2530
  Improvement of Levisa Fork............ I, 376; III, 2529
  Improvement of Tug Fork............ I, 375; III, 2528
Big Sunflower River, Miss., improvement of............ I, 308; III, 1935
Bills authorizing construction of bridges, examination of............ I, 24
Birmingham, Ala.:
  Examination for canal to Black Warrior River............ I, 275; II, 1704
  Survey for canal to Black Warrior River............ I, 275; II, 1704
Biscayne Bay, Fla., survey of............ I, 252; II, 1588
Bishop and Clerks Light, Vineyard Sound, Mass., removal of wreck near.. I, 80, 928
Bismarck Harbor, N. Dak. *See* Missouri River between Stubbs Ferry and Sioux City.
Black Lake, Mich.:
  Improvement of Holland Harbor............ I, 426; IV, 2916
  Survey of Holland Harbor............ I, 435; IV, 2950
Black River, Ark. and Mo., improvement of............ I, 313; III, 1975
Black River, La., improvement of............ I, 302; III, 1904
Black River, Mich.:
  Bridge at Port Huron, construction of............ I, 534
  Improvement of, at Port Huron............ I, 446; IV, 3022
  Improvement of mouth of............ I, 446; IV, 3021
Black River, N. Y., examination of, to harbor at Dexter............ I, 482; IV, 3306
Black River, N. C., improvement of............ I, 207; II, 1402
Black River, Ohio, improvement of harbor at Lorain............ I, 457; IV, 3072
Black River, Wash., construction of bridge across............ I, 531
Black Rock Harbor, N. Y., survey of Buffalo entrance to............ I, 473; IV, 3245
Black Warrior River, Ala.:
  Bridge in Tuscaloosa County, construction of............ I, 530
  Canal to Birmingham, examination for............ I, 275; II, 1704
  Canal to Birmingham, survey for............ I, 275; II, 1704
  Improvement of, below Tuscaloosa............ I, 265; II, 1678
  Improvement of, between Tuscaloosa and Daniels Creek............ I, 264; II, 1667
  Locks and dams on, operating and care of............ I, 265; II, 1675
Blind Slough, Oreg., construction of bridge across............ I, 533
Block Island, R. I.:
  Construction of harbor of refuge at............ I, 78, 922
  Improvement of Great Salt Pond............ I, 79, 925
Blood River, La., improvement of............ I, 279; II, 1753
Board of Engineers, The............ I, 4, 553
Bœuf River, La., improvement of............ I, 303; III, 1917
Bogue Chitto, La., improvement of............ I, 274; II, 1703
Bogue Falia, La., improvement of............ I, 278; II, 1751
Bogue Inlet, N. C., examination and survey for jetty near...... I, 211; II, 1418, 1421
Bogue Sound, N. C., improvement of waterway via............ I, 205; II, 1398
Boonville, Mo., construction of bridge across Missouri River at............ I, 529
Boonville and Howard County Bridge Company, bridge of............ I, 529
Boothbay Harbor, Me., examination of............ I, 43, 802
Boston Harbor, Mass.:
  Defenses at............ I, 7, 12, 600
  Harbor lines in Charles River at Cambridge, modification of............ I, 23, 881
  Improvement of............ I, 55, 843
Bourne, Mass., construction of bridges by town of............ I, 534
Braddock and Duquesne Bridge Company, bridge of............ I, 530
Braddock Township, Pa., construction of bridge across Monongahela River to Mifflin Township............ I, 530
Brandon (bark), removal of wreck of, from Man of War Harbor, Key West, Fla............ I, 251; II, 1566
Branford, Conn., removal of wreck at Thimble Islands east of............ I, 138, 1156
Brave Boat Harbor, Me., construction of bridge across............ I, 534

anals, etc.:
See also Waterways.
Albemarle and Chesapeake Canal, N. C., improvement of waterway via ... I, 195; II, 1374
Allegheny River, Pa., construction of locks and dams on ... I, 363; III, 2428
Barren River, Ky., operating and care of locks and dams on ... I, 370; III, 2462
Birmingham to Black Warrior River, Ala., examination for ... I, 275; II, 1704
Birmingham to Black Warrior River, Ala., survey for ... I, 275; II, 1704
Black Warrior River, Ala., operating and care of locks and dams on. I, 265; II, 1675
Black Warrior River to Birmingham, Ala., examination for ... I, 275; II, 1704
Black Warrior River to Birmingham, Ala., survey for ... I, 275; II, 1704
Cape Cod Ship Canal, Mass., examination of approaches to ... I, 64, 864
Cascades Canal, Columbia River, Oreg., construction of ... I, 504; IV, 3416
Cascades Canal, Columbia River, Oreg., operating and care of ... I, 505; IV, 3423
Clubfoot and Harlowe Canal, N. C., improvement of waterway via. I, 204; II, 1395
Cod, Cape, Ship Canal, Mass., examination of approaches to ... I, 64, 864
Columbia River, Oreg., construction of Cascades Canal ... I, 504; IV, 3416
Columbia River, Oreg., operating and care of Cascades Canal ... I, 505; IV, 3423
Coosa River, Ga. and Ala., operating and care of locks and dams. I, 262; II, 1654
Davis Island Dam, Ohio River, Pa., operating and care of ... I, 356; III, 2354
Des Moines Rapids Canal and Dry Dock, Mississippi River, operating and care of ... I, 323; III, 2104
Duluth Canal, Minn. *See* Duluth Harbor.
Erie Canal, N. Y., preservation of bench marks along ... I, 546; VI, 4122
Erie Canal, N. Y., widening locks of, to permit passage of war vessels ... I, 473; IV, 3250
Fox River, Wis., construction of bridge across canal at Appleton ... I, 532
Fox River, Wis., operating and care of locks and dams ... I, 407; IV, 2719
Galena River, Ill., operating and care of lock and dam ... I, 323; III, 2109
Galveston and Brazos Canal, Tex., examination of ... I, 298; II, 1809
Gowanus Canal, New York Harbor, N. Y., improvement of ... I, 125, 1118
Gowanus Canal, New York Harbor, N. Y., removal of wreck in ... I, 138, 1158
Great Kanawha River, W. Va., operating and care of locks and dams ... I, 383; III, 2575
Great Lakes to Hudson River, examination for ship canal ... I, 472; IV, 3128
Green River, Ky., construction of Lock and Dam No. 5 ... I, 370; III, 2459
Green River, Ky., operating and care of locks and dams ... I, 370; III, 2462
Green River, Ky., reconstruction of Lock No. 2, at Rumsey ... I, 369; III, 2457
Green River, Ky., survey at mouth, for new lock and dam ... I, 373; III, 2504
Hudson River to Great Lakes, examination for ship canal ... I, 472; IV, 3128
Illinois and Mississippi Canal, Ill., construction of ... I, 418; IV, 2825
Illinois and Mississippi Canal., Ill., operating and care of canal around rapids of Rock River ... I, 420; IV, 2880
Illinois River, Ill., operating and care of Lagrange and Kampsville locks and dams ... I, 417; IV, 2822
Kentucky River, Ky., operating and care of locks and dams ... I, 375; III, 2519
Little Kanawha River, W. Va., operating and care of lock and dam ... I, 384; III, 2582
Louisville and Portland Canal, Ky., operating and care of ... I, 366; III, 2444
Michigan Lake to Sturgeon Bay, Wis., construction of harbor of refuge at eastern entrance ... I, 397; IV, 2671
Michigan Lake to Sturgeon Bay, Wis., improvement of ... I, 396; IV, 2660
Michigan Lake to Sturgeon Bay, Wis., operating and care of ... I, 397; IV, 2666
Mississippi River, construction of Lock and Dam No. 2, between St. Paul and Minneapolis ... I, 323; III, 2110
Mississippi River, operating and care of Des Moines Rapids Canal and Dry Dock ... I, 323; III, 2104
Monongahela River, acquisition of improvements of Monongahela Navigation Company ... I, 361; III, 2411
Monongahela River, acquisition of Locks and Dams Nos. 6 and 7. I, 361; III, 2411
Monongahela River, operating and care of Locks and Dams Nos. 8 and 9 ... I, 360; III, 2409
Morgan Canal, Tex., improvement of ... I, 294; II, 1803
Morgan Canal, Tex., operating and care of ... I, 298; II, 1808
Muscle Shoals Canal, Tennessee River, Ala., operating and care of. I, 351; III, 2296
Muskingum River, Ohio, operating and care of locks and dams .. I, 358; III, 2364
Northern and Northwestern Lakes to Hudson River, examination for ship canal ... I, 472; IV, 3128
Ohio River, construction of Dams Nos. 2, 3, 4, 5, and 6 ... I, 356; III, 2358
Ohio River, operating and care of Davis Island Dam, Pa ... I, 356; III, 2354

Charlevoix Harbor, Mich.:
  Improvement of ... I, 433; IV, 2942
  Survey of ... I, 435; IV, 2953
Charlotte Harbor, Fla.:
  Examination of inside passage to Punta Rasa ... I, 252; II, 1572
  Improvement of ... I, 246; II, 1559
Charlotte Harbor, N. Y.:
  Improvement of ... I, 474; IV, 3269
  Water levels ... I, 547; VI, 4127, 4129
Charts. *See* Maps.
Chatham Harbor, Mass.:
  Improvement of ... I, 62, 858
  Removal of wreck in ... I, 928
Chattahoochee River, Ga. and Ala.:
  Improvement of, below Columbus, Ga ... I, 256; II, 1616
  Improvement of, between West Point and Franklin, Ga ... I, 257; II, 1620
Cheboygan Harbor, Mich., improvement of ... I, 440; IV, 3009
Chefuncte River, La., improvement of ... I, 278; II, 1751
Chehalis River, Wash., improvement of ... I, 510; IV, 3437
Chequamegon Bay, Wis. *See* Ashland Harbor.
Chesapeake Bay, Va. and Md.:
  Improvement of harbor at Cape Charles City, Va ... I, 194; II, 1370
  Removal of wreck in, abreast of Sassafras River, Md ... I, 171; II, 1289
Chester River, Md., improvement of ... I, 164; II, 1273
Chicago, Ill.:
  Examination of Illinois and Des Plaines rivers for extension of navigation to Lake Michigan, at or near ... I, 421; IV, 2882
  Improvement of channels in connecting waters of Great Lakes between Duluth, Buffalo, and ... I, 435; IV, 2955
  Improvement of Chicago River at ... I, 411; IV, 2793
  Improvement of harbor at ... I, 409; IV, 2790
  Improvement of South Chicago Harbor ... I, 412; IV, 2801
  Removal of wreck in North Branch, Chicago River ... I, 420; IV, 2881
Chicago and Northwestern Railway Company, bridges of ... I, 533
Chicago River, Ill. *See* Chicago.
Chickasahay River, Miss., improvement of ... I, 271; II, 1695
Chief of Engineers, Office of the ... I, 550
China (barge), removal of wreck of ... I, 420; IV, 2881
Chincoteague Bay, Va., improvement of waterway to Delaware Bay, Del ... I, 162; II, 1270
Chipola River, Fla., improvement of lower ... I, 254; II, 1609
Chippewa River, Wis., improvement of, including Yellow Banks ... I, 328; III, 2152
Chitto, Bogue, La., improvement of ... I, 274; II, 1703
Choctawhatchee River, Fla. and Ala., improvement of ... I, 257; II, 1621
Choptank River, Md.:
  Bridge at Denton, construction of ... I, 532
  Improvement of ... I, 164; II, 1275
  Survey of Cambridge Harbor ... I, 172; II, 1296
Christiana River, Del.:
  Improvement of ... I, 155; II, 1250
  Removal of wrecks in ... I, 170; II, 1288
Clearwater Harbor, Fla., examination of ... I, 252; II, 1578
Clearwater River, Idaho, improvement of ... I, 521; IV, 3465
Cleveland Harbor, Ohio:
  Improvement of ... I, 458; IV, 3075
  Water levels ... I, 547; VI, 4127, 4128
Clinch River, Tenn.:
  Bridge at Kingston, construction of ... I, 530
  Improvement of ... I, 353; III, 2311
Clinton River, Mich., improvement of ... I, 449; IV, 3027
Clubfoot and Harlowe Canal, N. C., improvement of waterway via ... I, 204; II, 1395
Clubfoot River, N. C., improvement of waterway via ... I, 204; II, 1395
Coanjock Bay, N. C., improvement of waterway via ... I, 195; II, 1374
Cocheco River, N. H., improvement of ... I, 40, 794
Cochran (steamer), removal of wreck of, from Man of War Harbor, Key West, Fla ... I, 251; II, 1566
Cod, Cape, Mass., removal of wreck off, near Orleans ... I, 63, 859
Cod, Cape, Ship Canal, Mass., examination of approaches to ... I, 64, 864
Cold Spring Bay, N. Y., examination for connecting Lloyds Harbor with ... I, 139, 1165
Coldwater River, Miss., examination of ... I, 310; III, 1943

Continuing contracts—Continued.
  Narragansett Bay, R. I ..... I, 74, 908
  Newtown Creek, N. Y ..... I, 128, 1125
  New York Harbor, N. Y., Bay Ridge, Red Hook, and Buttermilk channels ..... I, 125, 1117
  New York Harbor, N. Y., Newtown Creek ..... I, 128, 1125
  Northern and Northwestern Lakes, channels in connecting waters of ..... I, 435; IV, 2955
  Oakland Harbor, Cal ..... I, 484; IV, 3327
  Ohio River, Dams Nos. 2, 3, 4, 5, and 6 ..... I, 356; III, 2358
  Ohio River, Falls of, at Louisville, Ky., including Indiana Chute. I, 364; III, 2441
  Plaquemine Bayou, La ..... I, 282; II, 1759
  Point Judith, R. I., harbor of refuge ..... I, 77, 918
  Portland Harbor, Me., including Back Cove ..... I, 37, 790
  Providence River, R. I ..... I, 74, 908
  Rivers and harbors ..... I, 22
  Rockland Harbor, Me ..... I, 33, 783
  Sabine Pass, Tex., harbor at ..... I, 288; II, 1771
  Savannah Harbor, Ga ..... I, 224; II, 1493
  Superior Harbor, Wis ..... I, 386; III, 2592
  Superior Lake to Keweenaw Bay, Mich., waterway from ..... I, 389; III, 2608
  Vicksburg Harbor, Miss ..... I. 306; III, 1927
  Willamette River above Portland, Oreg ..... I, 506; IV, 3429
  Wilmington Harbor, Cal ..... I, 486; IV, 3335
  Wilmington Harbor, Del ..... I, 155; II, 1250
  Winyah Bay, S. C ..... I, 217; II, 1452
  Yamhill River, Oreg ..... I, 506; IV, 3429
  Yaquina Bay, Oreg ..... I, 499; IV, 3394
  Yazoo River, Miss., mouth of ..... I, 306; III, 1927
Contracts, continuing. *See* Continuing contracts.
Cooper Creek, N. J., improvement of ..... I, 152; II, 1223
Cooper River, S. C., establishment of harbor lines in ..... I, 23; II, 1487
Coosa River, Ga. and Ala.:
  Improvement of ..... I, 261; II, 1642
  Improvement of, between Rome, Ga., and East Tennessee, Virginia and Georgia Railroad Bridge ..... I, 261; II, 1642
  Improvement of, between Wetumka, Ala., and East Tennessee, Virginia and Georgia Railroad Bridge ..... I, 262; II, 1647
  Operating and care of locks and dams on ..... I, 262; II, 1654
Coos Bay, Oreg.:
  Improvement of entrance and harbor ..... I, 496; IV, 3384
  Improvement of harbor by dredging ..... I, 497; IV, 3387
Coos River, Oreg., improvement of ..... I, 498; IV, 3388
Coquille River, Oreg.:
  Improvement of, between Coquille City and Myrtle Point ..... I, 496; IV, 3383
  Improvement of mouth ..... I, 495; IV, 3380
Corporations, occupancy or injury of public structures by ..... I, 24, 536; VI, 3981
Corps of Engineers:
  Changes during the year ..... I, 3
  Laws of Fifty-fourth Congress, second session, and Fifty-fifth Congress, first session, affecting the ..... VI, 4151, 4197
  Number and distribution of officers ..... I, 3
  Officers detached ..... I, 4
Corpus Christi Channel, Tex., construction of bridge across ..... I, 530
Cos Cob Harbor, Conn., improvement of ..... I, 102, 969
Courtableau Bayou, La., improvement of ..... I, 283; II, 1762
Cowlitz River, Wash., improvement of ..... I, 520; IV, 3463
Crystal River, Fla., examination of ..... I, 252; II, 1580
Cumberland River, Tenn. and Ky.:
  Gauging ..... I, 23, 309; III, 1936
  Improvement of, above Nashville, Tenn ..... I, 344; III, 2223
  Improvement of, below Nashville, Tenn ..... I, 342; III, 2220
  Survey of mouth of ..... I, 347; III, 2242
Cumberland Sound, Ga. and Fla.:
  Defenses of ..... I, 17, 700
  Improvement of ..... I, 235; II, 1526
Current River, Ark. and Mo., improvement of ..... I, 314; III, 1978
Currituck Sound, N. C., improvement of waterway through ..... I, 195; II, 1374
Curtis Bay, Md., improvement of channel in Patapsco River to ..... I, 173; II, 1306
Cut-off, Apalachicola River, Fla., improvement of ..... I, 254; II, 1609

Dunkirk Harbor, N. Y., improvement of ... I, 464; IV, 3103
Duwamish River, Wash., improvement of ... I, 511; IV, 3438
Duxbury Beach, Mass. *See* Duxbury Harbor.
Duxbury Harbor, Mass.:
  Examination of ... I, 63, 860
  Examination of Duxbury Beach ... I, 64, 862

E.

Eads, James B., improvement of South Pass, Mississippi River, by representatives of ... I, 25, 277; II, 1731
East Chester Creek, N. Y.:
  Examination of ... I, 140, 1175
  Improvement of ... I, 118, 1089
Eastern Branch, Elizabeth River, Va. *See* Elizabeth River.
East River, Ga. *See* Brunswick Harbor.
East River, N. Y.:
  Bridge at New York City, construction of ... I, 532
  Examination of Wallabout Channel ... I, 115, 1047
  Harbor lines at New York City, establishment of ... I, 23, 1081
  Improvement of ... I, 111, 1026
East River, Wis., construction of bridge across, at Green Bay ... I, 532
East River Bridge Company, bridge of ... I, 532
Edgartown, Marthas Vineyard, Mass., improvement of inner harbor at ... I, 68, 890
Edgewater, N. J., removal of wreck in Hudson River, below ... I, 114, 1040
Egyptian Levee, Des Moines River, Iowa and Mo., survey of ... I, 325; III, 2124
Elizabeth River, N. J.:
  Improvement of ... I, 131, 1134
  Survey of ... I, 141, 1185
Elizabeth River, Va.:
  Bridge across Southern Branch at Norfolk, construction of ... I, 533
  Norfolk Harbor and its approaches, improvement of ... I, 190; II, 1353
  Waterway to Albemarle Sound, N. C., improvement of ... I, 195; II, 1374
  Western Branch, improvement of ... I, 191; II, 1365
  Wreck in Southern Branch, removal of ... I, 198; II, 1380
Elk River, W. Va., improvement of ... I, 380; III, 2565
Elliott Bay, Wash., improvement of waterway via ... I, 513; IV, 3445
Ellis Island, New York Harbor, N. Y., modification of harbor lines at ... I, 23, 1075
Ellsworth, Me., examination of Union River near ... I, 42, 800
Embankments ... I, 8
Emory River, Tenn., survey of, up to Harriman ... I, 354; III, 2316
Emplacements. *See* Fortifications.
Employees injured while engaged upon public works, necessity of legislation for relief of ... I, 25
Engineer Depot, Willets Point, N. Y ... I, 6, 22, 574
Engineer divisions ... I, 25
Engineers, Battalion of ... I, 6, 22, 570
Engineer School, Willets Point, N. Y ... I, 5, 22, 562
Engineers, Corps of. *See* Corps of Engineers.
Engineers, division ... I, 25
Engineers, Office of the Chief of ... I, 550
Engineers, The Board of ... I, 4, 553
Enterprise (schooner), removal of wreck of ... I, 80, 927
Erie Basin, Black Rock Harbor, N. Y., survey of Buffalo entrance to ... I, 473; IV, 3245
Erie Canal, N. Y.:
  Preservation of bench marks along ... I, 546; VI, 4122
  Widening locks of, to permit passage of war vessels ... I, 473; IV, 3250
Erie Harbor, Pa.:
  Harbor lines in Presque Isle Bay, establishment of ... I, 24; IV, 3265
  Improvement of ... I, 463; IV, 3097
  Survey of ... I, 473; IV, 3237
  Water levels ... I, 547; VI, 4127, 4128
  Wrecks in, removal of ... I, 472
Erie Lake:
  See also Northern and Northwestern Lakes.
  Defenses on ... I, 7, 20
  Examination of shoals in ... I, 547; VI, 4123
  Water levels ... I, 547; VI, 4127, 4128
Escambia River, Fla., improvement of ... I, 259; II, 1631

Fort Marion, Fla., preservation and repair of .... I, 17, 702
Fort Mifflin, Pa., rebuilding dike at .... I, 638
Fort Monroe, Va., sewerage system at .... I, 16, 663
Fort Montgomery, N. Y., preservation and repair of .... I, 744
Fort Niagara, N. Y., sea wall at .... I, 20, 743
Fort Schuyler, N. Y., sea wall at .... I, 611
Fort Smith, Ark.:
Improvement of Arkansas River at .... I, 311; III, 1952
Survey of Arkansas River at .... I, 316; III, 1989
Fox River, Wis.:
Bridge across United States canal at Appleton, construction of .... I, 532
Bridge at Green Bay, construction of .... I, 532
Bridge at Menasha, construction of .... I, 533
Improvement of .... I, 406; IV, 2709
Improvement of Green Bay Harbor .... I, 395; IV, 2657
Operating and care of locks and dams on .... I, 407; IV, 2719
Frankfort, Me., examination for removal of wreck in Marsh River .... I, 43, 801
Frankfort, Mich., improvement of harbor at .... I, 432; IV, 2939
Fredericka, Marie (ship), removal of wreck of, from Man of War Harbor, Key West, Fla .... I, 251; II, 1566
French Broad River, Tenn.:
Improvement of .... I, 352; III, 2308
Injury to training walls .... VI, 3983
Friend, Lottie K. (schooner), removal of wreck of .... II, 1227
Fulton, Ark.:
Improvement of Red River above .... I, 300; III, 1895
Improvement of Red River below .... I, 299; III, 1877

G.

Galena River, Ill., operating and care of lock and dam on .... I, 323; III, 2109
Galveston and Brazos Canal, Tex., examination of .... I, 298; II, 1809
Galveston and Brazos Navigation Company, examination of canal of. I, 298; II, 1809
Galveston Bay and Harbor, Tex.:
Galveston Bay, examination of channel to Brazos River .... I, 298; II, 1809
Galveston Bay, improvement of ship channel in .... I, 294; II, 1803
Galveston Harbor, defenses of .... I, 7, 19, 737
Galveston Harbor, improvement of .... I, 292; II, 1793
Galveston Island, survey at easterly end of .... I, 298; II. 1813
Morgan Canal, operating and care of .... I, 298; II, 1808
Morgan Cut and Canal, improvement of .... I, 294; II, 1803
West Galveston Bay, improvement of channel in .... I, 295; II, 1804
Galveston Island, Tex., survey at easterly end of .... I, 298; II, 1813
Gasconade River, Mo., improvement of, by Missouri River Commission. I, 527; VI, 3837
Gauging:
See also Hydraulics.
Columbia River, Oreg. and Wash .... I, 507; IV, 3432
Mississippi River and tributaries .... I, 23, 309; III, 1936
Mississippi River at St. Paul, Minn .... I, 332; III, 2164
Northern and Northwestern Lakes .... I, 547; VI, 4127
Gauley River, W. Va., improvement of .... I, 380; III, 2564
Gedney Channel, New York Harbor, N. Y.:
Improvement of .... I, 113; 1031
Removal of wreck in .... I, 114; 1039
Genesee River, N. Y. *See* Charlotte Harbor.
George Lake, St. Johns River, Fla. *See* Volusia Bar.
Georges River, Me., improvement of .... I, 35, 785
Georgetown, D. C. *See* Washington.
Georgia, defenses of coast of .... I, 7, 17, 700
Glencove Harbor, N. Y., improvement of .... I, 122, 1103
Gloucester Harbor, Mass., improvement of .... I, 49, 835
Goshen Creek, N. J., improvement of .... I, 153; II, 1225
Governor Marvin (steamer), removal of wreck of .... I, 251; II, 1566
Governors Island, New York Harbor, N. Y., survey of channel between the Battery and .... I, 141, 1182
Gowanus Bay channels, New York Harbor, N. Y.:
Improvement of .... I, 125, 1117
Survey of .... I, 140, 1177
Gowanus Canal, New York Harbor, N. Y.:
Improvement of .... I, 125, 1118
Removal of wreck in .... I, 138, 1158

Harbor lines, establishment of—Continued.
  Charles River at Cambridge, Mass ... I, 23, 881
  Charleston Harbor, S. C ... I, 23; II, 1487
  Cooper River, S. C ... I, 23; II, 1487
  Duluth Harbor, Minn ... I, 23; III, 2647
  East River at New York, N. Y ... I, 23, 1081
  Ellis Island, New York Harbor, N. Y ... I, 23, 1075
  Erie Harbor, Pa ... I, 24; IV, 3265
  Harlem River, N. Y ... I, 23, 1077
  Hudson River at New York, N. Y ... I, 23, 1067, 1070
  Kewaunee Harbor, Wis ... I, 24; IV, 2785
  New York Harbor, N. Y ... I, 23, 1067, 1070, 1075, 1077, 1081
  Olympia Harbor, Wash ... I, 24; IV, 3484
  Spuyten Duyvil Creek, N. Y ... I, 23, 1077
  Superior Bay, Minn. and Wis ... I, 23; III, 2647
  Superior Harbor, Wis ... I, 23; III, 2647
  Waukegan Harbor, Ill ... I, 24; IV, 2786
Harbors and rivers. *See* Rivers and harbors.
Harlem River, N. Y.:
  Bridge obstructing, at New York City ... I, 536
  Bridges across, location and characteristics of ... I, 1024
  Harbor lines at New York City, modification of ... I, 23, 1077
  Improvement of ... I, 110, 1019
Harlowe River, N. C., improvement of waterway via ... I, 204; II, 1395
Harraseeket River, Me., survey of ... I, 44, 815
Hartford, Conn., improvement of Connecticut River below ... I, 86, 948
Hat Slough, Wash., improvement of ... I, 511; IV, 3438
Havre de Grace, Md., improvement of Susquehanna River above and below ... I, 163; II, 1272
Hay Lake Channel, St. Marys River, Mich., improvement of ... I, 439; IV, 3006
Haynes, John C. (schooner), removal of wreck of ... I, 198; II, 1379
Helena Harbor, Ark., improvement of, by Mississippi River Commission. I, 525; V, 3505
Hell Gate, East River, N. Y., improvement of ... I, 111, 1026
Hempstead, N. Y.:
  See also Glencove Harbor.
  Construction of bridge across Long Beach Channel, by town of ... I, 533
Henderson Harbor, N. Y., removal of wreck in ... I, 482; IV, 3304
Herr Island, Allegheny River, Pa., construction of lock and dam at. I, 363; III, 2428
Hillebrandt Bayou, Tex., construction of bridge across ... I, 533
Hillsboro Bay, Fla., examination of ... I, 252; II, 1574
Hillsboro River, Fla.:
  Examination of, up to Tampa ... I, 252; II, 1574
  Removal of wreck in, at Tampa ... I, 251; II, 1566
Hogansburg, N. Y., construction of bridge across St. Lawrence River near. I, 531
Holland (Black Lake) Harbor, Mich.:
  Improvement of ... I, 426; IV, 2916
  Survey of ... I, 435; IV, 2950
Holway, L. (schooner), removal of wreck of ... I, 42, 798
Homochitto River, Miss., examination of ... I, 291; II, 1777
Horn Island Pass and Harbor, Miss.:
  Improvement of Horn Island Pass ... I, 270; II, 1693
  Survey of ... I, 276; II, 1716
Horre, William (tug), removal of wreck of ... I, 138, 1158
Housatonic River, Conn.:
  Improvement of ... I, 92, 956
  Survey of ... I, 105, 979
Houston, East and West Texas Railway Company, bridge of ... I, 534
Hudson River, N. Y. and N. J.:
  Examination for ship canal to Great Lakes ... I, 472; IV, 3128
  Examination of Nyack Harbor, N. Y ... I, 115, 1044
  Harbor lines at New York, N. Y., modification of ... I, 23, 1067, 1070
  Improvement of, between Coxsackie and Troy, N. Y ... I, 105, 996
  Improvement of Peekskill Harbor, N. Y ... I, 109, 1016
  Wrecks at Jersey City and Edgewater, N. J., removal of ... I, 114, 1039, 1040
Humboldt Harbor and Bay, Cal.:
  Examination of Eureka Harbor ... I, 494; IV, 3377
  Improvement of ... I, 492: IV, 3366
Huntington Harbor, N. Y., improvement of ... I, 121, 1100
Huron Harbor, Ohio, improvement of ... I, 455; IV, 3064

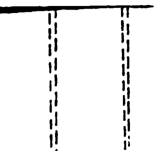
entucky River, Ky.:
  Improvement of .... I, 373; III, 2513
  Operating and care of locks and dams on .... I, 375; III, 2519
ewaunee Harbor, Wis.:
  Harbor lines at, establishment of .... I, 24; IV, 2785
  Improvement of .... I, 399; IV, 2675
eweenaw Bay, Mich., improvement and operating and care of waterway to Lake Superior .... I, 389, 390; III, 2608
eweenaw Point, Mich., waterway across. *See* Keweenaw Bay.
eyport Harbor, N. J., improvement of .... I, 135, 1147
ey West Harbor, Fla.:
  Defenses at .... I, 7, 17, 703
  Improvement of northwest entrance of .... I, 244; II, 1555
  Wrecks in Man of War Harbor, removal of .... I, 251; II, 1566
ingston, Tenn., construction of bridge across Clinch River at .... I, 530
innickinick River, Wis., construction of bridges across, at Milwaukee .... I, 533
ittery, Me., construction of bridges to Badgers Island and York .... I, 534
ootenai River, Idaho and Mont.:
  Improvement of, between Bonners Ferry, and international boundary .... I, 521; IV, 3467
  Survey of, above Jennings, Mont .... I, 523; IV, 3482

L.

a Crosse Harbor, Wis.:
  Improvement of .... I, 322; III, 2059
  Survey of .... I, 325; III, 2116
afourche Bayou, La., improvement of .... I, 281; II, 1757
agrange Lock and Dam, Illinois River, Ill., operating and care of.. I, 417; IV, 2822
ake Charles, La., construction of bridge across Calcasieu River at .... I, 531
ake City, Ark., construction of bridge across Lake St. Francis near .... I, 531
akes, Great. *See* Northern and Northwestern Lakes.
ake Shore and Michigan Southern Railway Company:
  Bridge of, at Ashtabula, Ohio .... I, 534
  Bridge of, at Toledo, Ohio .... I, 531
akes, Northern and Northwestern. *See* Northern and Northwestern Lakes.
a Trappe River, Md.:
  Improvement of .... I, 165; II, 1276
  Survey of .... I, 171; II, 1295
aurie, Annie (tug), removal of wreck of .... I, 472
aws:
  Compilation of, for maintenance of navigable waters .... I, 24; VI, 4137
  Fifty-fourth Congress, second session, and Fifty-fifth Congress, first session, affecting Corps of Engineers .... VI, 4151, 4197
  Necessity of, for relief of injured employees on public works .... I, 25
eaf River, Miss., improvement of .... I, 272; II, 1697
eague Island, Pa., removal of wreck in Delaware River opposite .... I, 153; II, 1227
eech Lake, Minn.:
  Operating and care of reservoir at .... I, 328; III, 2142
  Reservoir at .... I, 326; III, 2137
egislation. *See* Laws.
emon Creek, Staten Island, N. Y. *See* Staten Island—New Jersey channel.
evert, J. B., bridge of .... I, 534
evisa Fork, Big Sandy River, Ky., improvement of .... I, 376; III, 2529
ewes, Del.:
  Construction of iron pier in Delaware Bay, near .... I, 147; II, 1213
  Improvement of waterway from Chincoteague Bay, Va., to Delaware Bay, near .... I, 162; II, 1270
ewis River, Wash.:
  Examination of North Fork, to head of navigation .... I, 523; IV, 3469
  Survey of, up to Lacenter .... I, 523; IV, 3473
Lippitt, Henry (schooner), removal of wreck of .... I, 198; II, 1379
Little Assawaman Bay, Del., improvement of waterway via .... I, 162; II, 1270
Little Harbor, Mass. *See* Woods Hole Channel.
Little Harbor, N. H., improvement of harbor of refuge at .... I, 41, 796
Little Kanawha River, W. Va.:
  Improvement of .... I, 384; III, 2582
  Operating and care of lock and dam on .... I, 384; III, 2582
Little Pedee River, S. C., improvement of .... I, 215; II, 1444
Little Pigeon River, Tenn., improvement of .... I, 352; III, 2310

Marie Fredericka (ship), removal of wreck of, from Man of War Harbor, Key West, Fla. I, 251; II, 1566
Marion County, Miss., bridge of I, 530
Marion, Fort, Fla., preservation and repair of I, 17, 702
Marquette Bay, Mich. *See* Marquette Harbor.
Marquette Harbor, Mich.:
  Construction of harbor of refuge at Presque Ile Point I, 391; III, 2638
  Improvement of I, 391; III, 2615
  Water levels I, 547; VI, 4127, 4129
Marsh River, Me., examination for removal of wreck at Frankfort I, 43, 801
Marthas Vineyard, Mass., improvement of inner harbor at Edgartown I, 68, 890
Marvin, Governor (steamer), removal of wreck of I, 251; II, 1566
Massachusetts, defenses of southeast coast of I, 7, 12, 603
Mattaponi River, Va., improvement of I, 185; II, 1342
Mattawan Creek, N. J.:
  Improvement of I, 134, 1145
  Improvement of Keyport Harbor I, 135, 1147
Mattituck Harbor, N. Y., improvement of I, 119, 1095
Maumee Bay and River, Ohio. *See* Toledo Harbor.
Memphis Harbor, Tenn., improvement of, by Mississippi River Commission I, 525; V, 3505
Menasha, Wis., construction of bridge across Fox River, by city of I, 533
Menominee Harbor, Mich. and Wis.:
  Improvement of I, 393; IV, 2650
  Survey of I, 408; IV, 2751
Menominee River, Mich. and Wis., improvement of I, 393; IV, 2652
Mermentau River, La., improvement of, and tributaries I, 285; II, 1767
Merrimac River, Mass.:
  Dredging between Newburyport and Haverhill, estimate of cost of I, 64, 865
  Improvement of I, 46, 827
  Improvement of Newburyport Harbor I, 45, 824
Mianus River, Conn., improvement of I, 102, 969
Michigan City Harbor, Ind., improvement of I, 421; IV, 2895
Michigan Lake:
  See also Northern and Northwestern Lakes.
  Construction of harbor of refuge at eastern entrance of canal between Sturgeon Bay and I, 397; IV, 2671
  Examination of Illinois and Des Plaines rivers, Ill., for extension of navigation to I, 421; IV, 2882
  Improvement of canal to Sturgeon Bay, Wis I, 396; IV, 2660
  Operating and care of canal to Sturgeon Bay, Wis I, 397; IV, 2666
  Survey of Wolf Lake and River, Ill. and Ind., with reference to their navigation in connection with I, 421; IV, 2887
  Water levels I, 547; VI, 4127, 4129
Middle Fork, Forked Deer River, Tenn.:
  Improvement of I, 340, 341; III, 2217
  Survey of I, 347; III, 2234
Mifflin, Fort, Pa., rebuilding dike at I, 638
Mifflin Township, Pa.:
  Construction of bridge across Monongahela River to Braddock Township. I, 530
  Construction of bridge across Monongahela River to Port Perry I, 529
Milan, Ill., operating and care of canal around rapids of Rock River at I, 420; IV, 2880
Military departments, reconnaissances and explorations in I, 547; VI, 4131
Millbridge, Me., removal of wreck in Narraguagus Bay at I, 42, 798
Mille Lacs Lake, Minn., examination of, for reservoir I, 332; III, 2170
Mill Neck Creek Inlet, N. Y., construction of bridge across, at Bayville I, 533
Mill River, Conn. *See* New Haven Harbor.
Milwaukee, Wis.:
  Bridges across Kinnickinick River, construction of I, 533
  Harbor of refuge in Milwaukee Bay, construction of I, 402; IV, 2689
  Improvement of harbor at I, 403; IV, 2692
  Survey of harbor at I, 408; IV, 2765
  Water levels I, 547; VI, 4127, 4129
  Wreck in Milwaukee Bay, removal of I, 407; IV, 2751
Milwaukee River and Bay, Wis. *See* Milwaukee.
Mines, submarine I, 11
Mingo Creek, S. C., improvement of I, 217; II, 1450
Mining, hydraulic, in California. *See* California Débris Commission.

26



Forwarded with my letter of July 31, 1896,
to the Presid't. of the Mo. River Commission.

Division Engineer.

Eng 55 2

27

Ontario, Canada, commerce passing, in 1896 ... IV, 2999, 3004

Ontario Lake:
- *See also* Northern and Northwestern Lakes.
- Defenses on ... I, 7, 20, 743
- Water levels ... I, 547; VI, 4127, 4129

Ontonagon Harbor, Mich., improvement of ... I, 389; III, 2606

Operating, care, and maintenance of certain public works, provision for ... I, 23

Orange River, Fla., examination of ... I, 251; II, 1569

Orleans, Mass., removal of wreck off Cape Cod, near ... I, 63, 859

Osage River, Mo.:
- Bridge at Osceola, construction of ... I, 531
- Improvement of, by Missouri River Commission ... I, 527; VI, 3837

Osceola, Mo., construction of bridge across Osage River at ... I, 531

Oswegatchie River, N. Y. *See* Ogdensburg Harbor.

Oswego Canal, N. Y., widening locks of, to permit passage of war vessels ... I, 483; IV, 3324

Oswego Harbor, N. Y.:
- Improvement of ... I, 476; IV, 3278
- Injury to structures at ... VI, 3986
- Water levels ... I, 547; VI, 4127, 4129

Otter Creek, Vt., improvement of ... I, 481; IV, 3299

Otter Tail Lake and River, Minn., examination of, for reservoir ... I, 333; III, 2172

Ouachita River, Ark. and La.:
- Bridge at Monroe, La., construction of ... I, 530
- Improvement of ... I, 302; III, 1904

Our Little Harry (barge), removal of wreck of ... I, 153; II, 1227

Oyster Bay, N. Y.:
- Construction of bridge across Mill Neck Creek Inlet, by town of ... I, 533
- Examination of harbor at ... I, 139, 1163

Oyster River, N. H., examination of ... I, 43, 804

P.

Pacific (scow), removal of wreck of ... I, 472

Palestine (schooner), removal of wreck of ... I, 153; II, 1227

Palmbeach, Fla., survey at ... I, 252; II, 1585

Pamlico River, N. C.:
- Improvement of ... I, 201; II, 1388
- Survey of, at and below Washington ... I, 212; II, 1425

Pamunkey River, Va., improvement of ... I, 187; II, 1344

Pascagoula River, Miss.:
- Improvement of ... I, 269; II, 1692
- Survey of, from mouth to Dog River, and up Dog River ... I, 276; II, 1718

Pasquotank River, N. C., improvement of ... I, 197; II, 1378

Passaic River, N. J., improvement of ... I, 129, 1128

Pass a Loutre, Mississippi River, closing crevasse in ... I, 291; II, 1776

Patapsco River, Md.:
- Improvement of channel to Curtis Bay ... I, 173; II, 1306
- Improvement of, including channel to Baltimore ... I, 172; II, 1299
- Improvement of Spring Garden, Baltimore ... I, 174; II, 1307
- Survey of Baltimore Harbor ... I, 174; II, 1308
- Wreck off Fort McHenry, removal of ... I, 174; II, 1307

Patchogue River, N. Y., improvement of ... I, 123, 1108

Pawcatuck River, R. I. and Conn., improvement of ... I, 82, 940

Pawtucket River, R. I., improvement of ... I, 73, 905

Pearl River, Miss.:
- Bridge in Marion County, construction of ... I, 530
- Carthage to Jackson, improvement from ... I, 273; II, 1700
- Edinburg to Carthage, improvement from ... I, 274; II, 1702
- Jackson, improvement below ... I, 272; II, 1698
- Survey of channel at mouth of ... I, 277; II, 1722

Pease Creek, Fla., improvement of ... I, 246; II, 1559

Peekskill Harbor, N. Y., improvement of ... I, 109, 1016

Penobscot River, Me.:
- Defenses of ... I, 7, 11
- Examination for removal of wreck in Marsh River, Frankfort ... I, 43, 801
- Improvement of ... I, 30, 779
- Survey of Bangor Harbor and ... I, 44, 811

Pensacola Harbor, Fla.:
- Defenses of ... I, 7, 18, 714
- Improvement of ... I, 258; II, 1625

Portland Channel (Canal), Alaska, survey of .... i, 524; iv, 3487
Port Orford Harbor, Oreg., improvement of .... i, 494; iv, 3379
Port Perry, Pa., construction of bridge across Monongahela River at .... i, 529
Portsmouth, N. H., defenses at .... i, 7, 11, 597
Portsmouth, Kittery and York Street Railway Company, bridges of .... i, 534
Port Tobacco River, Md. *See* Chapel Point Harbor.
Port Washington Harbor, Wis., improvement of .... i, 401; iv, 2687
Portwing Harbor, Wis., examination of .... i, 393; iii, 2643
Potecasi Creek, N. C., examination of .... i, 199; ii, 1383
Potomac River:
  Aqueduct Bridge at Washington, D. C., repair of .... i, 536; vi, 3987
  Great Falls Dam, raising height of .... i, 540; vi, 4018
  Improvement of, at Washington, D. C .... i, 175; ii, 1313
  Unauthorized occupancy of Potomac Flats .... vi, 3981
Powow River, Mass., improvement of .... i, 47, 829
Presque Ile Point, Marquette Bay, Mich., construction of harbor of refuge .... i, 391; iii, 2638
Presque Isle Bay and Peninsula, Erie Harbor, Pa. *See* Erie Harbor.
Providence River, R. I.:
  Improvement of .... i, 74, 908
  Removal of Green Jacket Shoal .... i, 75, 911
Provincetown Harbor, Mass.:
  Improvement of .... i, 62, 856
  Survey of .... i, 66, 878
Public buildings and grounds, District of Columbia, improvement and care .... i, 542; vi, 4025
Public works:
  Necessity of legislation for relief of injured employees engaged on .... i, 25
  Occupancy and injury of .... i, 24, 536; vi, 3981
  Provision for operating, care, and maintenance of certain .... i, 23
Puget Sound, Wash.:
  Defenses of .... i, 7, 21, 763
  Improvement of, and tributaries .... i, 511; iv, 3438
  Improvement of waterway to lakes Union and Washington .... i, 513; iv, 3445
Pultneyville Harbor, N. Y., improvement of .... i, 474; iv, 3272
Punta Rasa, Fla., examination of inside passage to Charlotte Harbor. i, 252; ii, 1572

Q.

Queen Anne's Railroad Company, bridge of .... i, 532
Queens County, N. Y., bridge of .... i, 535
Queenstown Harbor, Md., improvement of .... i, 169; ii, 1286
Quinnipiac River, Conn. *See* New Haven Harbor.

R.

Racine Harbor, Wis.:
  Improvement of .... i, 404; iv, 2698
  Survey of .... i, 409; iv, 2768
Rahway River, N. J., survey of, up to Rahway .... i, 142, 1187
Raisin River, Mich.:
  Examination of .... i, 463; iv, 3094
  Improvement of Monroe Harbor .... i, 452; iv, 3037
Rancocas River, N. J., improvement of .... i, 150; ii, 1219
Rankin, Pa., construction of bridge across Monongahela River at .... i, 533
Rappahannock River, Va., improvement of .... i, 181; ii, 1331
Raritan Bay, N. J.:
  Improvement of .... i, 133, 1142
  Removal of wreck in .... i, 138, 1157
Raritan River, N. J.:
  Improvement of .... i, 132, 1136
  Removal of wreck in .... i, 138, 1157
Reconnaissances and explorations in military departments .... i, 547; vi, 4131
Red Bank, N. J., site for defenses at .... i, 639
Red Hook Channel and triangular area to Bay Ridge Channel, New York Harbor, N. Y.:
  Improvement of .... i, 125, 1117
  Survey of .... i, 140, 1177
Red Lake and Red Lake River, Minn.:
  Examination of, for reservoir .... i, 333; iii, 2173
  Improvement of .... i, 330; iii, 2159

t. Joseph Harbor, Mich.:
  Improvement of .... I, 423; IV, 2905
  Removal of wreck in .... I, 434; IV, 2947
t. Joseph River, Mich.:
  Bridge in Berrien County, construction of .... I, 533
  Improvement of .... I, 424; IV, 2909
  Improvement of St. Joseph Harbor .... I, 423; IV, 2905
  Wreck in St. Joseph Harbor, removal of .... I, 434; IV, 2947
t. Joseph Valley Railway Company, bridge of .... I, 533
t. Lawrence River, N. Y.:
  Bridge near Hogansburg, construction of .... I, 531
  Improvement of .... I, 478; IV, 3290
  Improvement of Cape Vincent Harbor .... I, 477; IV, 3286
  Improvement of Ogdensburg Harbor .... I, 479; IV, 3292
t. Louis, Mo., improvement of Mississippi River at .... I, 320; III, 2046
t. Louis Bay, Minn. and Wis., improvement of, at Duluth, Minn., and Superior, Wis .... I, 386; III, 2592
t. Louis River, Minn. and Wis.:
  Bridge between Duluth, Minn., and Superior, Wis., construction of .... I, 533
  Improvement of, at Duluth, Minn., and Superior, Wis .... I, 386; III, 2592
St. Martin Parish, La.:
  Construction of bridge across Bayou Teche by J. B. Levert .... I, 534
  Construction of bridge across Bayou Teche at St. Martinville by .... I, 534
St. Martinville, La., construction of bridge across Bayou Teche at .... I, 534
St. Marys Falls Canal, Mich.:
  Commerce passing, during 1896 .... IV, 2999, 3004
  Damage to Fort Brady Pier .... VI, 3985
  Operating and care of .... I, 438; IV, 2997
St. Marys River, Mich.:
  Commerce passing St. Marys Falls Canal in 1896 .... IV, 2999, 3004
  Damage to pier at Sault Ste. Marie .... VI, 3985
  Improvement of, at the falls .... I, 437; IV, 2963
  Improvement of Hay Lake Channel .... I, 439; IV, 3006
  Operating and care of St. Marys Falls Canal .... I, 438; IV, 2997
  Resurvey of .... I, 545; VI, 4070
  Water levels at Sault Ste. Marie .... I, 547; VI, 4127
  Wreck, removal of .... I, 451; IV, 3033
St. Paul, Minn., gauging Mississippi River at or near .... I, 332; III, 2164
Sakonnet Point, R. I., survey of .... I, 81, 934
Sakonnet River, R. I.:
  Improvement of .... I, 72, 904
  Survey of Sakonnet Point .... I, 81, 934
Salem, Mass., bridge to Beverly, construction of .... I, 532
Salem River, N. J., examination of, up to Salem City .... I, 155; II, 1245
Salmon Bay, Wash., improvement of waterway via .... I, 513; IV, 3445
Salmon Creek, N. Y. *See* Pultneyville Harbor.
Sand Beach, Lake Huron, Mich.:
  Improvement of harbor of refuge at .... I, 444; IV, 3015
  Water levels .... I, 547; VI, 4127
San Diego Harbor, Cal.:
  Defenses of .... I, 7, 20, 745
  Improvement of .... I, 487; IV, 3337
Sandusky Harbor, Ohio, improvement of .... I, 454; IV, 3052
Sandy Bay, Cape Ann, Mass., construction of harbor of refuge at .... I, 49, 832
Sandy Hook, N. J., defenses at .... I, 7, 14, 618
Sandy Lake, Minn.:
  Operating and care of reservoir at .... I, 328; III, 2142
  Reservoir at .... I, 326; III, 2137
San Francisco, Cal., defenses of .... I, 7, 20, 744, 748
San Francisco Bay, Cal.:
  Defenses of .... I, 7, 20, 744, 748
  Improvement of Oakland Harbor .... I, 484; IV, 3327
San Joaquin River, Cal.:
  Improvement of .... I, 488; IV, 3357
  Improvement of, and tributaries, by California Débris Commission .... I, 528; VI, 3961
San Leandro Estuary, Oakland, Cal. *See* Oakland Harbor.
San Luis Obispo Harbor, Cal., improvement of .... I, 485; IV, 3333
San Pedro Bay, Cal. *See* Wilmington.
Santee River, S. C., improvement of .... I, 219; II, 1456

VEL. 1 TO 2	4.62	4.70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
. 2 . 3	5.25	4.20	3.33	5.50	1.33	2.67	2.20
. 3 . 4	4.40	3.50	2.00	5.00	1.94	2.75	3.50
. 4 . 5	5.50	4.62	3.43	2.30	5.50	2.62	2.00
. 5 . 6	5.25	3.50	5.50	7.00	2.70	4.20	1.44
. 6 . 7	5.00	4.00	7.00	2.86	6.75	5.50	
. 7 . 8	7.00	2.22	3.50	5.25	1.54	2.50	.74
. 8 . 9	2.86	4.00	2.33	5.25	5.26	7.33	
. 9 . 10	3.50	2.63	3.33	4.00	6.67	5.20	.91
. 10 . 11	3.67				5.20	5.20	1.07
. 11 . 12					4.40	3.50	.48

Forwarded with my letter dated July 29. 1896,
to the Presid't of the Mo. River Commission

Saml. H. Yonge
Division Engineer.

Eng 55 2

- Twelve Mile Creek, N. Y. *See* Wilson Harbor.
- Two Rivers Harbor, Wis., improvement of .... I, 399; IV, 2678

U.

- Umpqua River, Oreg., improvement of .... I, 498; IV, 3389
- Union Lake, Wash., improvement of waterway via .... I, 513; IV, 3445
- Union Railroad Company, bridge of .... I, 529
- Union River, Me.:
  - Examination of, near Ellsworth .... I, 42, 800
  - Improvement of .... I, 29, 777
- Union Street Railway Company, bridge of .... I, 535
- United States:
  - Engineer School, Willets Point, N. Y .... I, 5, 22, 562
  - Occupancy or injury of structures built by .... I, 24, 536; VI, 3981
- Urbana Creek, Va., improvement of .... I, 183; II, 1335
- Use of structures built by the United States .... I, 24, 536; VI, 3981

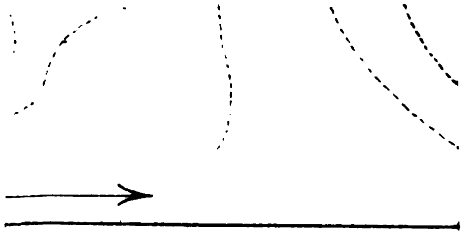
V.

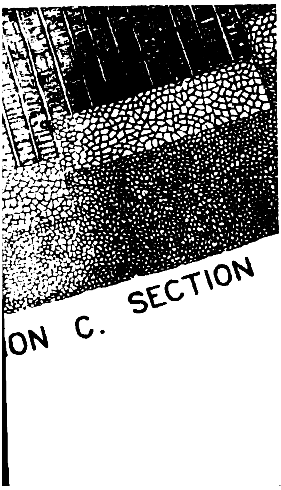
- Valley Creek, Ala., canal from Black Warrior River to Birmingham, via:
  - Examination for .... I, 275; II, 1704
  - Survey for .... I, 275; II, 1704
- Vanburen, Ark.:
  - Improvement of Arkansas River at .... I, 311; III, 1952
  - Survey of Arkansas River at .... I, 316; III, 1989
- Vermilion Bayou, La., improvement of channel, bay, and passes of .... I, 285; II, 1766
- Vermilion Harbor, Ohio, improvement of .... I, 456; IV, 3068
- Vermont and Province Line Railroad Company, bridge of .... I, 535
- Vicksburg Harbor, Miss.:
  - Improvement of .... I, 306; III, 1927
  - Obstruction of mouth, by small craft .... VI, 3982
- Vidalia Harbor, La., improvement of, by Mississippi River Commission .... I, 525; V, 3505
- Vinalhaven, Me., improvement of Carvers Harbor .... I, 34, 785
- Vincennes, Ind.:
  - Improvement of Wabash River above .... I, 367; III, 2453
  - Improvement of Wabash River below .... I, 367; III, 2452
- Vineyard Haven, Mass., improvement of harbor at .... I, 69, 892
- Vineyard Sound, Mass., removal of wrecks in .... I, 80, 927, 928
- Volusia Bar, St. Johns River, Fla., improvement of .... I, 240; II, 1550

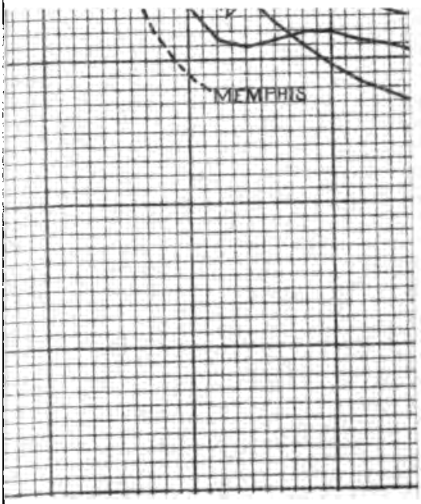
W.

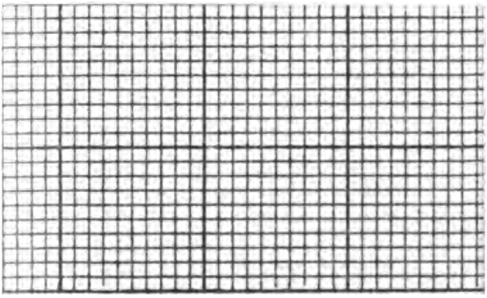
- Wabash River, Ind. and Ill.:
  - Improvement of .... I, 366; III, 2452
  - Improvement of, above Vincennes, Ind .... I, 367; III, 2453
  - Improvement of, below Vincennes, Ind .... I, 367; III, 2452
  - Operating and care of lock and dam on .... I, 368; III, 2455
- Waccamaw River, N. C. and S. C., improvement of .... I, 213; II, 1439
- Wading River, N. J., examination of .... I, 154; II, 1238
- Wakefield, Va., monument and wharf at .... I, 543; VI, 4061
- Wallabout Channel, N. Y., examination of .... I, 115, 1047
- Walton County, Fla., bridge of .... I, 534
- Wappoo Cut, S. C., improvement of .... I, 223; II, 1479
- Warrior River, Ala.:
  - Bridge in Tuscaloosa County, construction of .... I, 530
  - Canal to Birmingham, examination for .... I, 275; II, 1704
  - Canal to Birmingham, survey for .... I, 275; II, 1704
  - Improvement of, below Tuscaloosa .... I, 265; II, 1678
  - Improvement of, between Tuscaloosa and Daniels Creek .... I, 264; II, 1667
  - Operating and care of locks and dams above Tuscaloosa .... I, 265; II, 1675
- Warwick River, Md., improvement of .... I, 166; II, 1277
- Washington, D. C.:
  - Aqueduct Bridge across Potomac River, repair of .... I, 536; VI, 3987
  - Defenses of .... I, 7, 15, 650
  - Potomac River at, improvement of .... I, 175; II, 1313
  - Potomac River Flats, unauthorized occupancy of .... VI, 3981
  - Public buildings and grounds and Washington Monument. I, 542; VI, 4025, 4032
  - Washington Aqueduct, increasing water supply of city of .... I, 540; VI, 4018
  - Washington Aqueduct, maintenance and repair of .... I, 537; VI, 3991
  - Washington Aqueduct, raising height of Great Falls Dam .... I, 540; VI, 4018
  - Washington Monument, care and maintenance of .... I, 542; VI, 4032

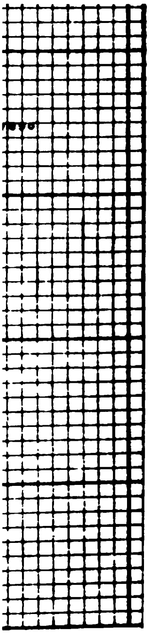
Wilmington, Del.:
  Improvement of harbor at .... I, 155; II, 1250
  Removal of wrecks in harbor at .... I, 170; II, 1288
Wilmington, N. C.:
  Defenses at .... I, 7, 16, 670
  Improvement of Cape Fear River above .... I, 208; II, 1404
  Improvement of Cape Fear River at and below .... I, 209; II, 1406
Wilson Harbor, N. Y., improvement of .... I, 471; IV, 3126
Winnibigoshish Lake, Minn.:
  Operating and care of reservoir at .... I, 338; III, 2142
  Reservoir at .... I, 326; III, 2137
Winyah Bay, S. C., improvement of .... I, 217; II, 1452
Withlacoochee River, Fla., improvement of .... I, 249; II, 1564
Wolf Lake and River, Ill. and Ind., survey of .... I, 421; IV, 2887
Woodbury Creek, N. J., rebuilding dike in Delaware River at .... I, 152, 639; II, 1223
Woods Hole Channel, Mass., improvement of .... I, 69, 894
Wrecks, removal of .... I, 23
  Baltimore Harbor, Md .... I, 174; II, 1307
  Bishop and Clerks Light, Vineyard Sound, Mass .... I, 80, 928
  Branford, Conn .... I, 138, 1156
  Brooklyn, N. Y .... I, 138, 1158
  Cape Cod, near Orleans, Mass., off .... I, 63, 859
  Chatham, Mass .... I, 928
  Chesapeake Bay, Md .... I, 171; II, 1289
  Chicago River at Chicago, Ill .... I, 420; IV, 2881
  Christiana River, Del .... I, 170; II, 1288
  Cod, Cape, near Orleans, Mass., off .... I, 63, 859
  Columbia River, Oreg .... I, 502; IV, 3406
  Darien Harbor, Ga .... I, 237; II, 1538
  Delaware Bay and River .... I, 153; II, 1227
  Edgewater, N. J .... I, 114, 1040
  Elizabeth River, Va .... I, 198; II, 1380
  Erie Harbor, Pa .... I, 472
  Fort Hamilton, New York Harbor, N. Y .... I, 114, 1039
  Fort McHenry, Baltimore Harbor, Md .... I, 174; II, 1307
  Frankfort, Me .... I, 43, 801
  Gedney Channel, New York Harbor, N. Y .... I, 114, 1039
  Gowanus Canal, New York Harbor, N. Y .... I, 138, 1158
  Great Egg Harbor Inlet, N. J .... I, 153; II, 1227
  Hamilton, Fort, New York Harbor, N. Y .... I, 114, 1039
  Hampton Roads, Va .... I, 198; II, 1379
  Henderson Harbor, N. Y .... I, 482; IV, 3304
  Hillsboro River, Fla .... I, 251; II, 1566
  Hudson River, at Jersey City and Edgewater, N. J .... I, 114, 1039, 1040
  Jersey City, N. J .... I, 114, 1039
  Key West Harbor, Fla .... I, 251; II, 1566
  League Island, Delaware River, Pa .... I, 153; II, 1227
  McHenry, Fort, Baltimore Harbor, Md .... I, 174; II, 1307
  Man of War Harbor, Key West, Fla .... I, 251; II, 1566
  Marsh River, at Frankfort, Me .... I, 43, 801
  Millbridge, Me .... I, 42, 798
  Milwaukee Bay, Wis .... I, 407; IV, 2751
  Mississippi River .... I, 23, 317; III, 2001
  Money Point, Elizabeth River, Va .... I, 198; II, 1380
  Narraguagus Bay, Me .... I, 42, 798
  Newport News, Va .... I, 198; II, 1379
  New York Harbor, N. Y .... I, 114, 138, 1039, 1040, 1158
  Norfolk Harbor, Va .... I, 198; II, 1380
  Norton Shoal, Vineyard Sound, Mass .... I, 80, 927
  Old Point Comfort Wharf, Va., near .... I, 198; II, 1379
  Orleans, Mass .... I, 63, 859
  Patapsco River, Md .... I, 174; II, 1307
  Penobscot River, Me., Marsh River branch of .... I, 43. 801
  Pontchartrain Lake, La .... I, 291; II, 1776
  Raritan Bay, N. J .... I, 138, 1157
  Raritan River, N. J .... I, 138, 1157
  St. Joseph River at St. Joseph, Mich .... I, 434; IV, 2947
  St. Marys River, Mich .... I, 451; IV, 3033
  Sassafras River, Md., mouth of .... I, 171; II, 1289




ON C. SECTION


MEMPHIS



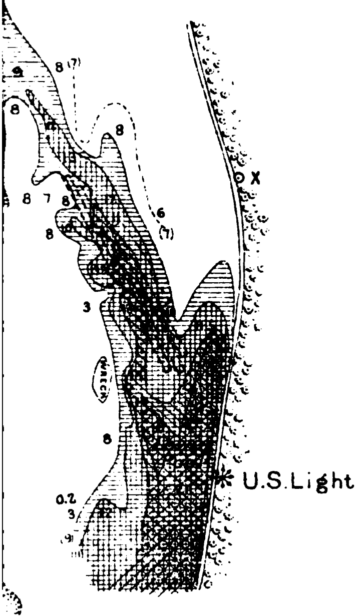


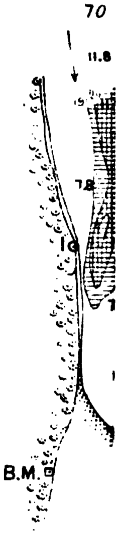
61

B

B96

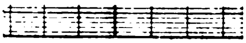
ing second time

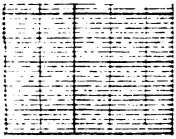


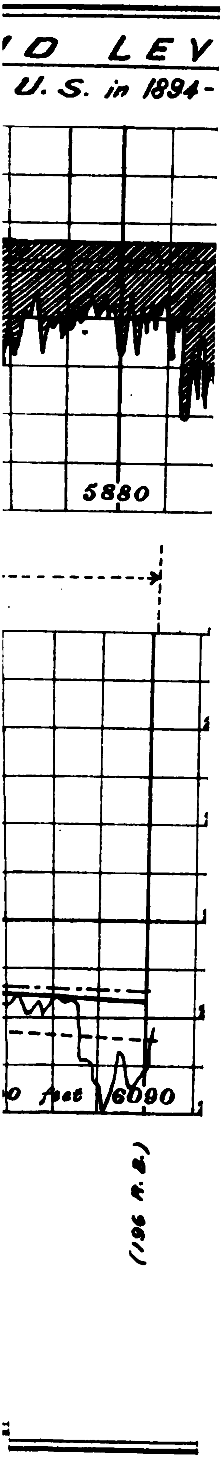


To accompany Annual

thus

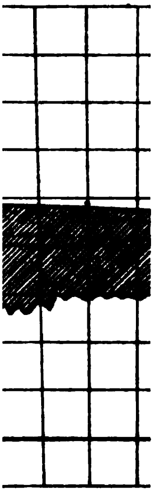


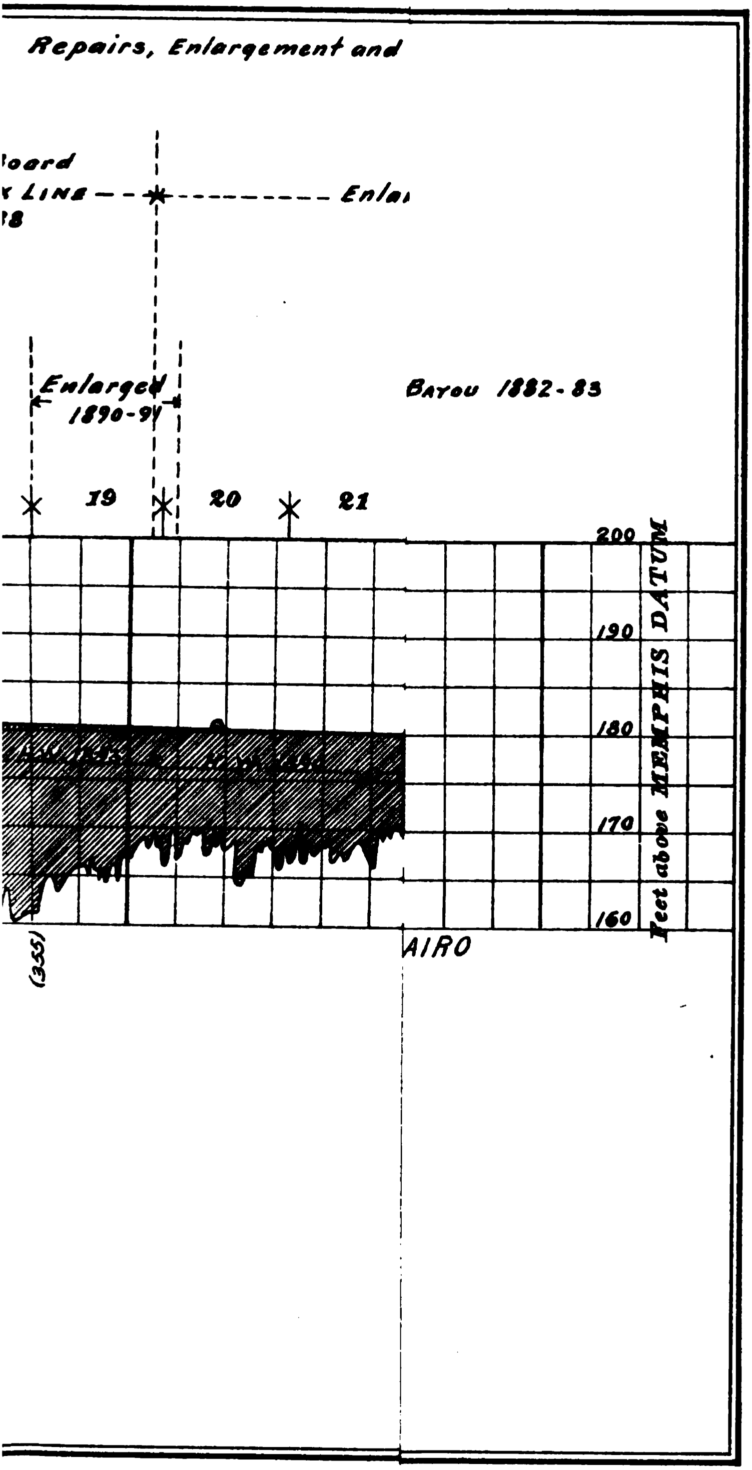


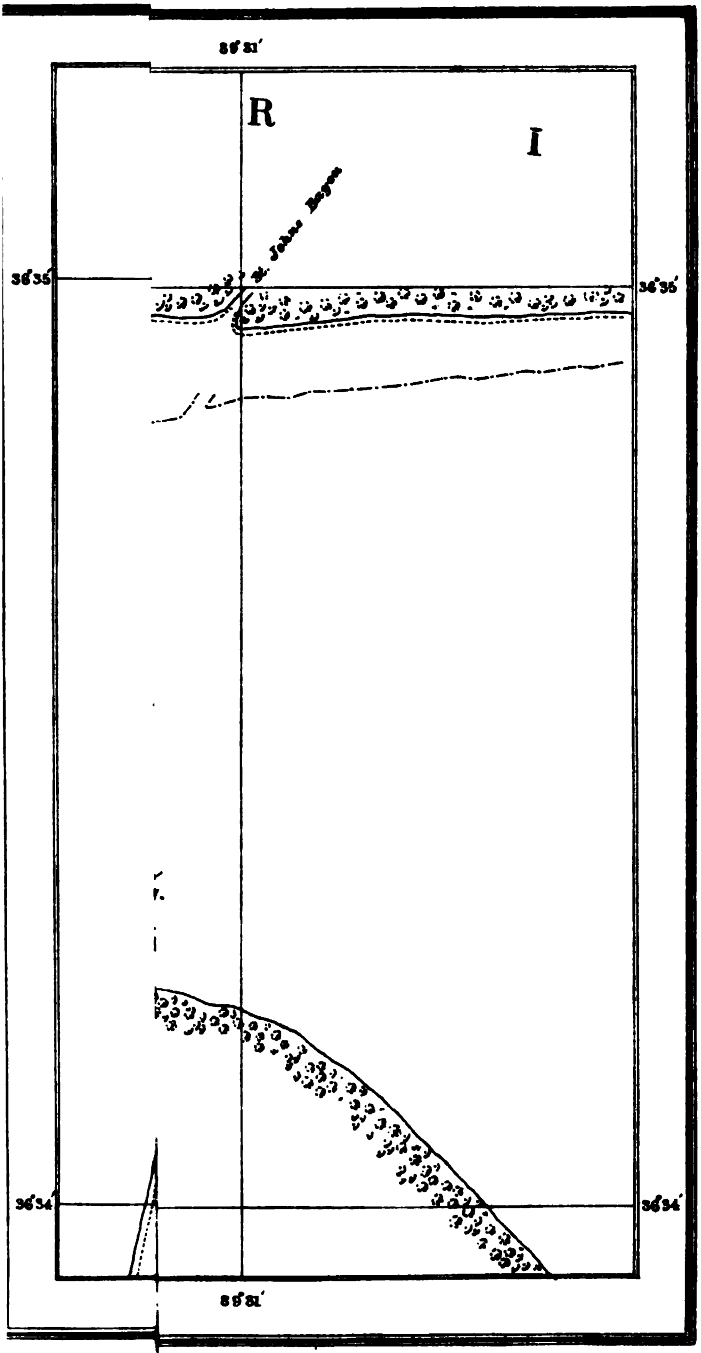

D LEV
U.S. in 1894-
5880
feet
6090
(196 R.B.)

ment & L

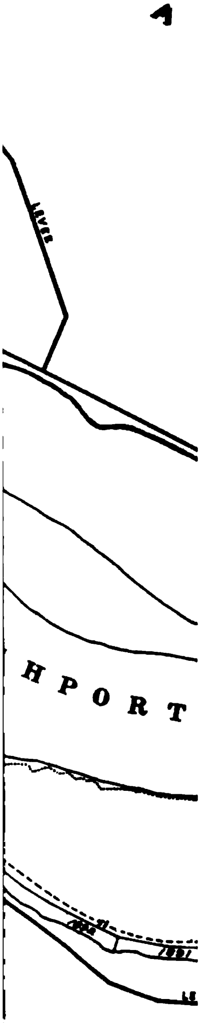
'argement

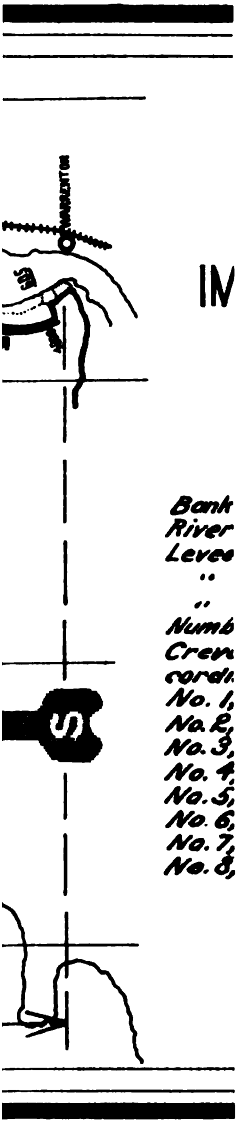


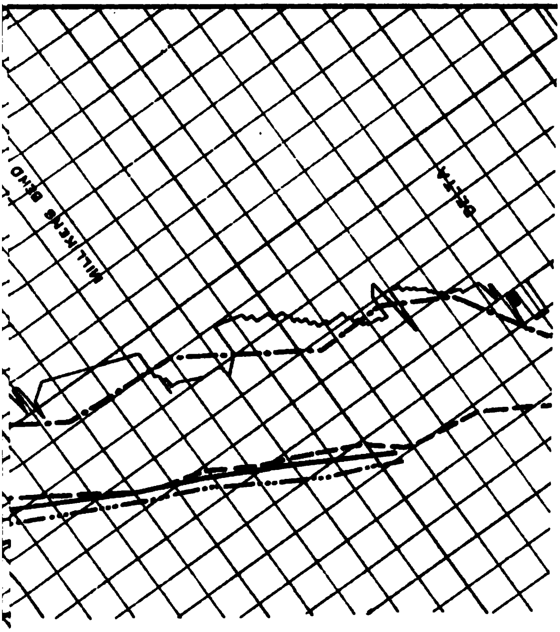

Repairs, Enlargement and
oard
LINE
8
Enla
Enlarged
1890-91
Bayou 1882-83
19
20
21
200
190
180
170
160
Feet above MEMPHIS DATUM
(335)
AIRO



Eng 55 2


LEVEE
HPORT
LE


IN
Bank
River
Levee
"
"
Numb
Crev
cordi
No. 1,
No. 2,
No. 3,
No. 4,
No. 5,
No. 6,
No. 7,
No. 8,
S



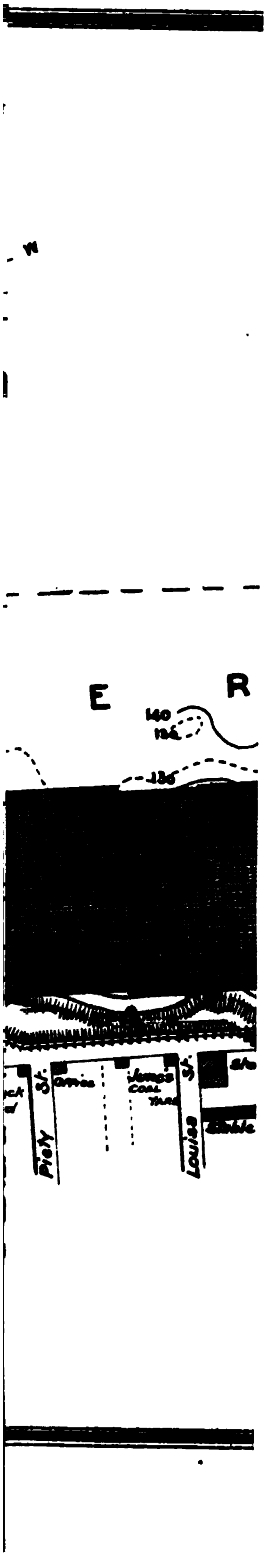
HIGH WATER SLOPES
IN THE
PPER TENSAS LEVEE DISTRICT.

LEGEND.

———— *Indicates Levees previous to H.W. 1897.*
·········· *" H.W. 1890.* | – – – *Indicates H.W. 1892.*
-··-·· *" H.W. 1891.* | ——— *" H.W. 1893.*
—·—·—·—·— *Indicates H.W. 1897.*

TO ACCOMPANY ANNUAL REPORT. MAY, 20. 1897.

H. C. Newcomer
1st LIEUT. OF ENGRS.


E
R
140
136
136
St.
Office
Jones Coal Yard
St.
Piety
Louisa
Stable

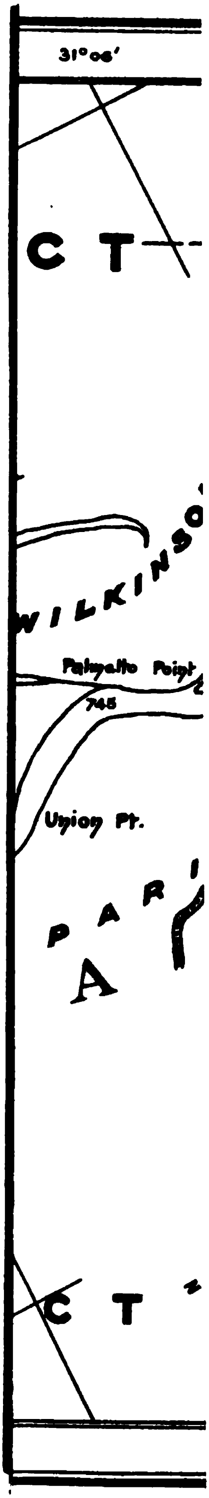
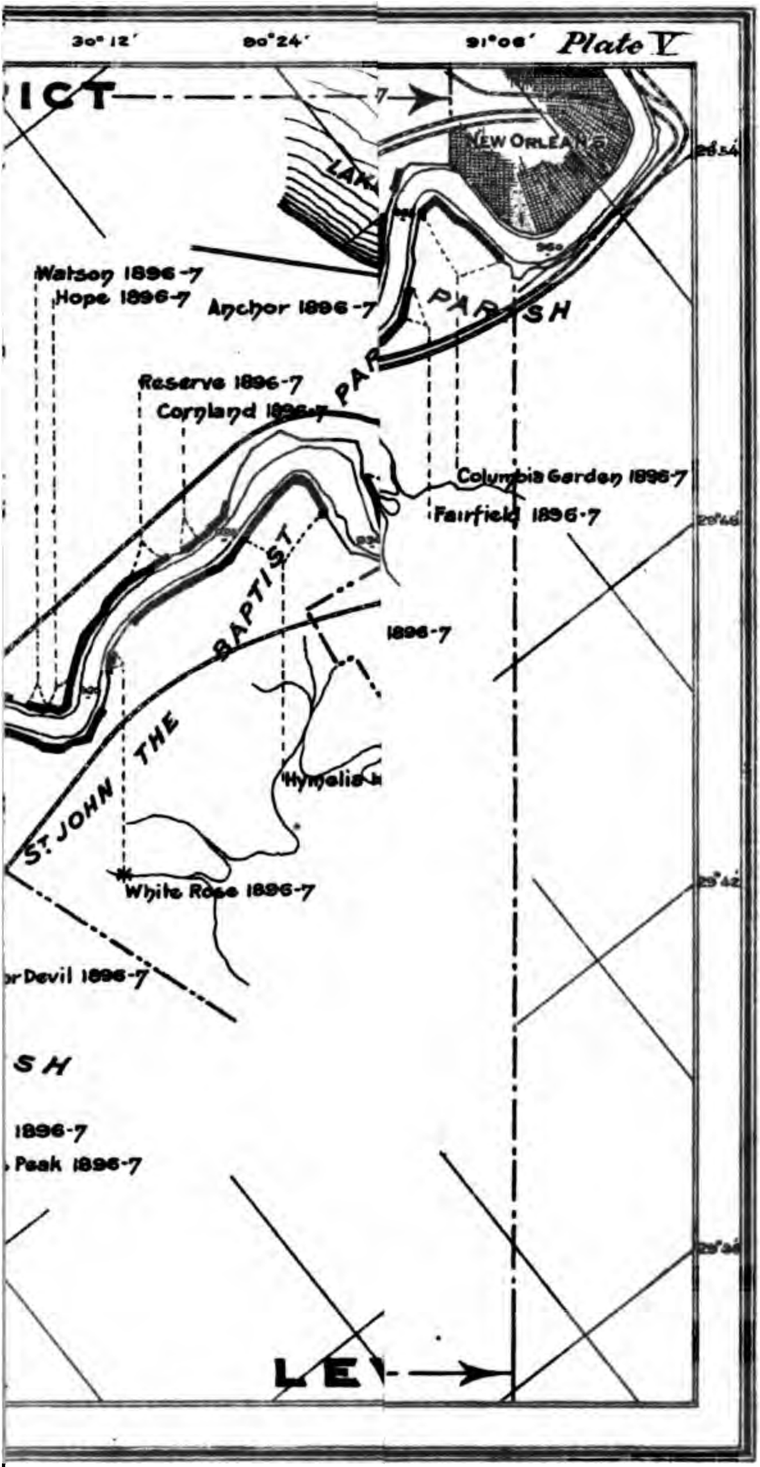

31°06'
C T
WILKINSO
Palmetto Point
745
Union Pt.
PARI
A
C T

Plate V


30° 12′
30° 24′
91° 08′
ICT
NEW ORLEANS
LAK
29 54
Watson 1896-7
Hope 1896-7
Anchor 1896-7
PARISH
Reserve 1896-7
Cornland 1896-7
PAR
Columbia Garden 1896-7
Fairfield 1896-7
29 48
ST JOHN THE BAPTIST
1896-7
Hymelia
White Rose 1896-7
29 42
r Devil 1896-7
SH
1896-7
Peak 1896-7
29 36
LE

INDEX.

[The references in Roman are to part (or volume), and those in Arabic to page.]

A.

See Laws.
hnet River, Mass. *See* New Bedford Harbor.
e Bay, Minn., improvement of harbor at........................ I, 386; III, 2588
ipee Harbor, Wis.:
  mprovement of.. I, 398; IV, 2672
  ccupancy of south pier.. VI, 3984
  Survey of... I, 408; IV, 2755
to injured employees engaged on public works, necessity of legislation for.. I, 25
a (steamship), removal of wreck of............................... I, 114, 1039
ama Great Northwestern Railway Company, bridge of................. I, 530
ama River, Ala.:
  Bridge near Montgomery, construction of........................ I, 530
  Improvement of.. I, 260; II, 1633
neda, Cal., alteration of bridge between Oakland and.............. I, 535
emarle and Chesapeake Canal, N. C., improvement of waterway via. I, 195; II, 1374
emarle Sound, N. C., improvement of waterway to Norfolk Harbor, Va.. I, 195; II, 1374
urgh Point, Vt., construction of bridge across Missisquoi Bay at....... I, 535
qua Creek, Fla., construction of bridge across, near Portland........... I, 534
xandria Bay, N. Y., examination of harbor at..................... I, 482; IV, 3312
egheny and Westmoreland Bridge Company, bridge of................ I, 533
egheny River, Pa.:
  Construction of locks and dams in.............................. I, 363; III, 2428
  Improvement of.. I, 362; III, 2424
ouez Bay, Wis., modification of harbor lines in.................. I, 23; III, 2647
oway Creek, N. J., improvement of................................ I, 150; II, 1220
ora (bark), removal of wreck of, from Man of War Harbor, Key West, Fla.. I, 251; II, 1566
ena Harbor, Mich., improvement of................................ I, 441; IV, 3011
ea River, Oreg., improvement of.................................. I, 499; IV, 3393
amaha River, Ga., improvement of................................. I, 230; II, 1513
ena (steamer), removal of wreck of.............................. I, 114, 1040
iso Creek, Cal., survey of.. I, 488; IV, 3343
ite River, La., improvement of.................................... I, 280; II, 1756
dura Creek, Va. *See* Nandua Creek.
na Augusta (schooner), removal of wreck of...................... I, 138, 1157
napolis Harbor, Md., survey of.................................... I, 175; II, 1309
n, Cape, Mass., construction of harbor of refuge at Sandy Bay..... I, 49, 832
to (bark), removal of wreck of, from Man of War Harbor, Key West, Fla.. I, 251; II, 1566
palachicola, Fla., survey of approaches to........................ I, 262; II, 1655
palachicola Bay, Fla.:
  Improvement of.. I, 254; II, 1605
  Survey of, including approaches to Apalachicola................ I, 262; II, 1655
palachicola River, Fla., improvement of, including the Cut-off.... I, 254; II, 1609
ppleton, Wis., construction of bridge across Fox River Canal at... I, 532
ppomattox River, Va., improvement of.............................. I, 193; II, 1369
ppoquinimink River, Del., improvement of.......................... I, 158; II, 1261
queduct Bridge, Potomac River, at Washington, D. C., repair of.... I, 536; VI, 3987
quia Creek, Va., improvement of................................... I, 179; II, 1324
ransas Harbor Terminal Railway Company, bridge of................. I, 530

Arkansas River, Ark. and Kans.:
  Gauging .... I, 23, 309:
  Improvement of .... I, 311:
  Removal of obstructions in .... I, 310:
  Surveys of, at Little Rock, Vanburen, Fort Smith, and Pinebluff, Ark .... I, 316; III,
Armament. *See* Fortifications.
Arthur Lake, La., improvement of .... I, 28
Ashland Harbor, Wis., improvement of .... I, 3
Ashley River, S. C., establishment of harbor lines in .... I, 23:
Ashtabula Harbor, Ohio:
  Bridge across Ashtabula River, construction of ....
  Improvement of .... I, 46
  Water levels .... I, 547; VI, 4
Ashtabula River, Ohio. *See* Ashtabula Harbor.
Assawaman Bay, Del., improvement of waterway via .... I, 16
Assistants to Chief of Engineers ....
Astoria and Columbia River Railroad Company, bridge of ....
Atchafalaya Bay, La., examination of .... I, 291:
Atchafalaya River, La., rectification of mouth, by Mississippi River Commission .... I, 525:
Augusta, Ga.:
  Improvement of Savannah River above .... I, 2
  Improvement of Savannah River below .... I, 227.
Augusta, Anna (schooner), removal of wreck of .... I,
Aux Becs Scies Lake, Mich. *See* Frankfort Harbor.

B.

Babylon Creek, N. Y., examination of .... I, 1
Back Cove, Portland, Me. *See* Portland.
Back River, Mass., construction of bridge across, at Bourne ....
Bagaduce River, Me., improvement of .... I,
Baker, Adelaide (schooner), removal of wreck of, from Man of War Harbor, Key West, Fla .... I, 251;
Balls Ferry, Cal., construction of bridge across Sacramento River at ....
Baltimore Harbor, Md.:
  Defenses of .... I, 7
  Improvement of channel to .... I, 172:
  Improvement of channel to Curtis Bay .... I, 173;
  Improvement of Spring Garden .... I, 174:
  Survey of .... I, 174:
  Wreck off Fort McHenry, removal of .... I, 174;
Bangor, Me.:
  Improvement of Penobscot River at .... I,
  Survey of Penobscot River at .... I, 4
Bar Harbor, Me., construction of breakwater from Mount Desert to Porcupine Island .... I,
Barnegat Bay, N. J., examination of .... I, 154; II
Barren River, Ky., operating and care of locks and dams on .... I, 370; III
Bartholomew Bayou, La. and Ark., improvement of .... I, 303; III
Bartrand River, S. C., examination of ....
Battalion of Engineers .... I, 6
Batteries. *See* Fortifications.
Battery, New York Harbor, N. Y., survey of channel between Governors Island and .... I, 14
Bay Ridge Channel and triangular area to Red Hook Channel, New York Harbor, N. Y.:
  Improvement of .... I, 12
  Survey of .... I, 14
Bayville, N. Y., construction of bridge across Mill Neck Creek Inlet at .... I,
Beach Ridge, Ark., prevention of Mississippi River from breaking into Cache River, near .... I, 321; III,
Beach Thoroughfare, N. J., examination of .... I, 154; II,
Beaufort Harbor, N. C.:
  Improvement of .... I, 204; II,
  Improvement of waterway to Newbern .... I, 204; II,
  Improvement of waterway to New River .... I, 205; II,
Beaufort Harbor, S. C., improvement of channel to Savannah, Ga .... I, 224; II, 1
Beaufort River, S. C., improvement of .... I, 224; II, 1

mont, Tex., construction of bridge across Neches River at............ I, 531
st Harbor, Me., improvement of............ I, 32, 781
Alice (schooner), removal of wreck of............ I, 153; II, 1227
my River, N. H., improvement of............ I, 40, 794
River, Mich., improvement of............ I, 448; IV, 3025
ngham Bay, Wash., survey of............ I, 523; IV, 3478
ɔn Harbor, Mich. *See* St. Joseph Harbor.
rly, Mass., construction of bridge between Salem and............ I, 532
County, Ala., construction of bridge across Cahaba River, in............ I, 530
ssawaman Bay, Del., improvement of waterway via............ I, 162; II, 1270
andy River, W. Va. and Ky.:
mprovement of............ I, 377; III, 2530
mprovement of Levisa Fork............ I, 376; III, 2529
mprovement of Tug Fork............ I, 375; III, 2528
unflower River, Miss., improvement of............ I, 308; III, 1935
authorizing construction of bridges, examination of............ I, 24
ingham, Ala.:
xamination for canal to Black Warrior River............ I, 275; II, 1704
urvey for canal to Black Warrior River............ I, 275; II, 1704
yne Bay, Fla., survey of............ I, 252; II, 1588
p and Clerks Light, Vineyard Sound, Mass., removal of wreck near.. I, 80, 928
arck Harbor, N. Dak. *See* Missouri River between Stubbs Ferry and Sioux City.
Lake, Mich.:
mprovement of Holland Harbor............ I, 426; IV, 2916
urvey of Holland Harbor............ I, 435; IV, 2950
k River, Ark. and Mo., improvement of............ I, 313; III, 1975
River, La., improvement of............ I, 302; III, 1904
k River, Mich.:
ridge at Port Huron, construction of............ I, 534
mprovement of, at Port Huron............ I, 446; IV, 3022
mprovement of mouth of............ I, 446; IV, 3021
k River, N. Y., examination of, to harbor at Dexter............ I, 482; IV, 3306
k River, N. C., improvement of............ I, 207; II, 1402
k River, Ohio, improvement of harbor at Lorain............ I, 457; IV, 3072
k River, Wash., construction of bridge across............ I, 531
k Rock Harbor, N. Y., survey of Buffalo entrance to............ I, 473; IV, 3245
k Warrior River, Ala.:
ridge in Tuscaloosa County, construction of............ I, 530
anal to Birmingham, examination for............ I, 275; II, 1704
anal to Birmingham, survey for............ I, 275; II, 1704
mprovement of, below Tuscaloosa............ I, 265; II, 1678
mprovement of, between Tuscaloosa and Daniels Creek............ I, 264; II, 1667
ocks and dams on, operating and care of............ I, 265; II, 1675
l Slough, Oreg., construction of bridge across............ I, 533
k Island, R. I.:
onstruction of harbor of refuge at............ I, 78, 922
mprovement of Great Salt Pond............ I, 79, 925
d River, La., improvement of............ I, 279; II, 1753
d of Engineers, The............ I, 4, 553
f River, La., improvement of............ I, 303; III, 1917
e Chitto, La., improvement of............ I, 274; II, 1703
e Falia, La., improvement of............ I, 278; II, 1751
e Inlet, N. C., examination and survey for jetty near...... I, 211; II, 1418, 1421
e Sound, N. C., improvement of waterway via............ I, 205; II, 1398
ville, Mo., construction of bridge across Missouri River at............ I, 529
ville and Howard County Bridge Company, bridge of............ I, 529
hbay Harbor, Me., examination of............ I, 43, 802
on Harbor, Mass.:
Defenses at............ I, 7, 12, 600
Harbor lines in Charles River at Cambridge, modification of............ I, 23, 881
Improvement of............ I, 56, 843
ne, Mass., construction of bridges by town of............ I, 534
dock and Duquesne Bridge Company, bridge of............ I, 530
dock Township, Pa., construction of bridge across Monongahela River to Mifflin Township............ I, 530
don (bark), removal of wreck of, from Man of War Harbor, Key West, Fla............ I, 251; II, 1566
ford, Conn., removal of wreck at Thimble Islands east of............ I, 138, 1156
e Boat Harbor, Me., construction of bridge across............ I, 534

- **Brazos River, Tex.:**
  - Examination of channel to Galveston Bay .... I, 298; II
  - Improvement of .... I, 297; II
  - Report upon improvements of Brazos River Channel and Dock Company .... I, 298; II
- **Brazos** River Channel and Dock Company, report upon improvements of .... I, 298; II
- **Breakwaters** built by the United States, occupancy or injury of.. I, 24, 536; VI
- Bridgeport Harbor, Conn.:
  - Bridge across Pequonnock River, construction of ....
  - Harbor lines at, modification of .... I,
  - Improvement of .... I,
- **Bridges:**
  - Alteration of .... I,
  - Construction of .... I,
  - Examination of bills authorizing construction of ....
  - Examination of plans and locations of proposed .... I, 24,
  - Obstructing navigation, action upon .... I,
- Bristol County, Mass., bridge of ....
- Broad Creek, Del. *See* Broad Creek River.
- Broad Creek River, Del., improvement of .... I, 167; II
- Broadkiln River, Del., improvement of .... I, 162; II
- Broad Sound, Mass. *See* Boston Harbor.
- Bronx River, N. Y., improvement of .... I, 11
- Brooklyn, N. Y.:
  - *See also* New York Harbor.
  - Alteration of city bridge across Newtown Creek, at Long Island City.. I,
  - Construction of city bridge across Coney Island Creek ....
  - Removal of wreck in Gowanus Canal .... I, 13
- Browns Creek, Sayville, N. Y., improvement of .... I, 1
- *Bruce* (schooner), removal of wreck of .... I, 451; IV
- Brunswick Harbor, Ga., improvement of .... I, 233; II
- Buffalo, N. Y.:
  - Improvement of channels in connecting waters of Great Lakes between Duluth, Chicago, and .... I, 435; IV
  - Improvement of harbor at .... I, 466; IV
  - Survey of Buffalo entrance to Erie Basin, Black Rock Harbor... I, 473; IV
- Buffalo Bayou, Tex., improvement of .... I, 296; II
- Buffalo Fork, White River, Ark., survey of .... I, 317; III
- Burlington Harbor, Vt., improvement of .... I, 480; IV
- Buttermilk Channel, New York Harbor, N. Y.:
  - Improvement of .... I, 125
  - Survey of .... I, 140
- Byram River and Harbor, N. Y. *See* Port Chester Harbor.

C.

- Cache River, Ark., prevention of Mississippi River from breaking into I, 321; III
- Cahaba River, Ala., construction of bridge across .... I,
- Cairo, Ill., prevention of Mississippi River from breaking into Cache River above .... I, 321; III
- Calais, Me., survey of St. Croix River below .... I, 4
- Calcasieu River, La.:
  - Bridge at Lake Charles, construction of .... I,
  - Improvement of mouth and passes of .... I, 286; II
- California Débris Commission .... I, 528; VI
- California, Department of, reconnaissances and explorations in..... I, 547; VI
- Caloosahatchee River, Fla.:
  - Examination of, from Orange River to Gulf of Mexico .... I, 251; II
  - Improvement of .... I, 245; II
- Calumet, Ill., improvement of harbor at .... I, 412; IV
- Calumet River, Ill. and Ind.:
  - Improvement of .... I, 414; IV
  - Improvement of harbor at Calumet, Ill .... I, 412; IV
- Cambridge, Md., survey of harbor at .... I, 172; II
- Cambridge, Mass., modification of harbor lines in Charles River at.......... I, 2
- Camden, Me., improvement of harbor at .... I, 3
- Camden, N. J.:
  - Improvement of Cooper Creek at .... I, 152; II
  - Improvement of Delaware River at .... I, 144; II

als, etc.:
See also Waterways.
Albemarle and Chesapeake Canal, N. C., improvement of waterway via........ I, 195; II, 1374
Allegheny River, Pa., construction of locks and dams on........ I, 363; III, 2428
Barren River, Ky., operating and care of locks and dams on.... I, 370; III, 2462
Birmingham to Black Warrior River, Ala., examination for...... I, 275; II, 1704
Birmingham to Black Warrior River, Ala., survey for............ I, 275; II, 1704
Black Warrior River, Ala., operating and care of locks and dams on. I, 265; II, 1675
Black Warrior River to Birmingham, Ala., examination for...... I, 275; II, 1704
Black Warrior River to Birmingham, Ala., survey for............ I, 275; II, 1704
Cape Cod Ship Canal, Mass., examination of approaches to........... I, 64, 864
Cascades Canal, Columbia River, Oreg., construction of......... I, 504; IV, 3416
Cascades Canal, Columbia River, Oreg., operating and care of... I, 505; IV, 3423
Clubfoot and Harlowe Canal, N. C., improvement of waterway via. I, 204; II, 1395
Cod, Cape, Ship Canal, Mass., examination of approaches to........... I, 64, 864
Columbia River, Oreg., construction of Cascades Canal.......... I, 504; IV, 3416
Columbia River, Oreg., operating and care of Cascades Canal... I, 505; IV, 3423
Coosa River, Ga. and Ala., operating and care of locks and dams. I, 262; II, 1654
Davis Island Dam, Ohio River, Pa., operating and care of....... I, 356; III, 2354
Des Moines Rapids Canal and Dry Dock, Mississippi River, operating and care of........ I, 323; III, 2104
Duluth Canal, Minn. *See* Duluth Harbor.
Erie Canal, N. Y., preservation of bench marks along............ I, 546; VI, 4122
Erie Canal, N. Y., widening locks of, to permit passage of war vessels........ I, 473; IV, 3250
Fox River, Wis., construction of bridge across canal at Appleton........ I, 532
Fox River, Wis., operating and care of locks and dams.......... I, 407; IV, 2719
Galena River, Ill., operating and care of lock and dam........... I, 323; III, 2109
Galveston and Brazos Canal, Tex., examination of................ I, 298; II, 1809
Gowanus Canal, New York Harbor, N. Y., improvement of............ I, 125, 1118
Gowanus Canal, New York Harbor, N. Y., removal of wreck in........ I, 138, 1158
Great Kanawha River, W. Va., operating and care of locks and dams........ I, 383; III, 2575
Great Lakes to Hudson River, examination for ship canal....... I, 472; IV, 3128
Green River, Ky., construction of Lock and Dam No. 5........... I, 370; III, 2459
Green River, Ky., operating and care of locks and dams.......... I, 370; III, 2462
Green River, Ky., reconstruction of Lock No. 2, at Rumsey..... I, 369; III, 2457
Green River, Ky., survey at mouth, for new lock and dam....... I, 373; III, 2504
Hudson River to Great Lakes, examination for ship canal....... I, 472; IV, 3128
Illinois and Mississippi Canal, Ill., construction of............. I, 418; IV, 2825
Illinois and Mississippi Canal., Ill., operating and care of canal around rapids of Rock River........ I, 420; IV, 2880
Illinois River, Ill., operating and care of Lagrange and Kampsville locks and dams........ I, 417; IV, 2822
Kentucky River, Ky., operating and care of locks and dams.... I, 375; III, 2519
Little Kanawha River, W. Va., operating and care of lock and dam........ I, 384; III, 2582
Louisville and Portland Canal, Ky., operating and care of....... I, 366; III, 2444
Michigan Lake to Sturgeon Bay, Wis., construction of harbor of refuge at eastern entrance........ I, 397; IV, 2671
Michigan Lake to Sturgeon Bay, Wis., improvement of.......... I, 396; IV, 2660
Michigan Lake to Sturgeon Bay, Wis., operating and care of..... I, 397; IV, 2666
Mississippi River, construction of Lock and Dam No. 2, between St. Paul and Minneapolis........ I, 323; III, 2110
Mississippi River, operating and care of Des Moines Rapids Canal and Dry Dock........ I, 323; III, 2104
Monongahela River, acquisition of improvements of Monongahela Navigation Company........ I, 361; III, 2411
Monongahela River, acquisition of Locks and Dams Nos. 6 and 7. I, 361; III, 2411
Monongahela River, operating and care of Locks and Dams Nos. 8 and 9........ I, 360; III, 2409
Morgan Canal, Tex., improvement of......................... I, 294; II, 1803
Morgan Canal, Tex., operating and care of....................... I, 298; II, 1808
Muscle Shoals Canal, Tennessee River, Ala., operating and care of. I, 351; III, 2296
Muskingum River, Ohio, operating and care of locks and dams.. I, 358; III, 2364
Northern and Northwestern Lakes to Hudson River, examination for ship canal........ I, 472; IV, 3128
Ohio River, construction of Dams Nos. 2, 3, 4, 5, and 6............ I, 356; III, 2358
Ohio River, operating and care of Davis Island Dam, Pa........ I, 356; III, 2354

Canals, etc.—Continued.

- Ohio River, operating and care of Louisville and Portland Canal, Ky .... I, 366
- Oswego Canal, N. Y., widening locks of, to permit passage of war vessels .... I, 483
- Portage Lake and Lake Superior canals, Mich., improvement and operating and care of .... I, 389, 39
- Portland Canal, Alaska, survey of .... I, 524
- Rock River, Ill., operating and care of canal around rapids of.. I, 42
- St. Clair Flats Canal, Mich., improvement of .... I, 445
- St. Clair Flats Canal, Mich., operating and care .... I, 44
- St. Marys Falls Canal, Mich., commerce passing, in 1896 IV
- St. Marys Falls Canal, Mich., damage to Fort Brady Pier ....
- St. Marys Falls Canal, Mich., operating and care .... I, 43
- Sturgeon Bay and Lake Michigan Canal, Wis., construction of harbor of refuge at eastern entrance .... I, 39
- Sturgeon Bay and Lake Michigan Canal, Wis., improvement of.. I, 39
- Sturgeon Bay and Lake Michigan Canal, Wis., operating and care. I, 39
- Superior Lake and Portage Lake canals, Mich., improvement and operating and care of .... I, 389, 39
- Tennessee River, operating and care of Muscle Shoals Canal, Ala. I, 351
- Wabash River, operating and care of lock and dam at Grand Rapids .... I, 3
- Warrior River, Ala., operating and care of locks and dams above Tuscaloosa .... I, 26
- Warrior River to Birmingham, Ala., examination for .... I, 27
- Warrior River to Birmingham, Ala., survey for .... I, 27

- Canapitsit Channel, Mass., improvement of ....
- Canarsie Bay, N. Y., improvement of I
- Cape Ann, Mass., construction of harbor of refuge at Sandy Bay ....
- Cape Charles City, Va., improvement of harbor at .... I, 194
- Cape Cod, Mass., removal of wreck off, near Orleans I
- Cape Cod Ship Canal, Mass., examination of approaches to I
- Cape Fear River, N. C.:
  - Improvement of, above Wilmington .... I, 208
  - Improvement of, at and below Wilmington .... I, 20
  - Improvement of North East River .... I, 207
- Cape Lookout harbor of refuge, N. C., survey of .... I, 212
- Cape Vincent, N. Y., improvement of harbor at .... I, 477; I
- Care, maintenance, and operating of certain public works, provision for...
- Carrabelle Bar and Harbor, Fla., improvement of .... I, 253; II
- Carrs Bend, Cal., examination of Napa River from Napa to, and for cut through .... I, 494; IV
- Carvers Harbor, Vinalhaven, Me., improvement of I
- Cascades Canal, Columbia River, Oreg.:
  - Construction of .... I, 504; IV
  - Operating and care of .... I, 505; I
- Casco Bay, Me., construction of bridge across, at Yarmouth ....
- Cashie River, N. C., examination of .... I, 199; II
- Catskill Creek, N. Y., examination of .... I, 11
- Cedar Creek, Del., examination of .... I, 171; II
- Cedar Keys, Fla., examination of harbor at .... I, 252; II
- Celilo Falls, Columbia River, Oreg. and Wash., construction of boat railway to The Dalles Rapids .... I, 505; I
- Central Pacific Railroad Company, bridge of ....
- Champlain Lake, N. Y. and Vt.:
  - Defenses on .... I, 7
  - Improvement of Burlington Harbor, Vt .... I, 480; IV
  - Improvement of channel between North and South Hero islands, Vt .... I, 480; IV
  - Improvement of Narrows of .... I, 481; IV
- Chandlers River, Me., examination of, from mouth to Jonesboro .... I, 4
- Chapel Point Harbor, Md., survey of .... I, 189; II
- Charles River, Mass.:
  - Harbor lines at Cambridge, modification of I
  - Improvement of I
- Charleston Harbor, S. C.:
  - Defenses at .... I, 7, 1
  - Harbor lines in Ashley and Cooper rivers, establishment of .... I, 23
  - Improvement of .... I, 222; I

- rlevoix Harbor, Mich.:
  - Improvement of … I, 433; IV, 2942
  - Survey of … I, 435; IV, 2953
- rlotte Harbor, Fla.:
  - Examination of inside passage to Punta Rasa … I, 252; II, 1572
  - Improvement of … I, 246; II, 1559
- rlotte Harbor, N. Y.:
  - Improvement of … I, 474; IV, 3269
  - Water levels … I, 547; VI, 4127, 4129
- rts. *See* Maps.
- tham Harbor, Mass.:
  - Improvement of … I, 62, 858
  - Removal of wreck in … I, 928
- ttahoochee River, Ga. and Ala.:
  - Improvement of, below Columbus, Ga … I, 256; II, 1616
  - Improvement of, between West Point and Franklin, Ga … I, 257; II, 1620
- boygan Harbor, Mich., improvement of … I, 440; IV, 3009
- functe River, La., improvement of … I, 278; II, 1751
- halis River, Wash., improvement of … I, 510; IV, 3437
- quamegon Bay, Wis. *See* Ashland Harbor.
- sapeake Bay, Va. and Md.:
  - Improvement of harbor at Cape Charles City, Va … I, 194; II, 1370
  - Removal of wreck in, abreast of Sassafras River, Md … I, 171; II, 1289
- ster River, Md., improvement of … I, 164; II, 1273
- icago, Ill.:
  - Examination of Illinois and Des Plaines rivers for extension of navigation to Lake Michigan, at or near … I, 421; IV, 2882
  - Improvement of channels in connecting waters of Great Lakes between Duluth, Buffalo, and … I, 435; IV, 2955
  - Improvement of Chicago River at … I, 411; IV, 2793
  - Improvement of harbor at … I, 409; IV, 2790
  - Improvement of South Chicago Harbor … I, 412; IV, 2801
  - Removal of wreck in North Branch, Chicago River … I, 420; IV, 2881
- icago and Northwestern Railway Company, bridges of … I, 533
- icago River, Ill. *See* Chicago.
- ickasahay River, Miss., improvement of … I, 271; II, 1695
- ief of Engineers, Office of the … I, 550
- *ina* (barge), removal of wreck of … I, 420; IV, 2881
- incoteague Bay, Va., improvement of waterway to Delaware Bay, Del … I, 162; II, 1270
- ipola River, Fla., improvement of lower … I, 254; II, 1609
- ippewa River, Wis., improvement of, including Yellow Banks … I, 328; III, 2152
- itto, Bogue, La., improvement of … I, 274; II, 1703
- octawhatchee River, Fla. and Ala., improvement of … I, 257; II, 1621
- optank River, Md.:
  - Bridge at Denton, construction of … I, 532
  - Improvement of … I, 164; II, 1275
  - Survey of Cambridge Harbor … I, 172; II, 1296
- hristiana River, Del.:
  - Improvement of … I, 155; II, 1250
  - Removal of wrecks in … I, 170; II, 1288
- learwater Harbor, Fla., examination of … I, 252; II, 1578
- learwater River, Idaho, improvement of … I, 521; IV, 3465
- leveland Harbor, Ohio:
  - Improvement of … I, 458; IV, 3075
  - Water levels … I, 547; VI, 4127, 4128
- linch River, Tenn.:
  - Bridge at Kingston, construction of … I, 530
  - Improvement of … I, 353; III, 2311
- linton River, Mich., improvement of … I, 449; IV, 3027
- lubfoot and Harlowe Canal, N. C., improvement of waterway via … I, 204; II, 1395
- lubfoot River, N. C., improvement of waterway via … I, 204; II, 1395
- oanjock Bay, N. C., improvement of waterway via … I, 195; II, 1374
- ocheco River, N. H., improvement of … I, 40, 794
- *ochran* (steamer), removal of wreck of, from Man of War Harbor, Key West, Fla … I, 251; II, 1566
- od, Cape, Mass., removal of wreck off, near Orleans … I, 63, 859
- od, Cape, Ship Canal, Mass., examination of approaches to … I, 64, 864
- old Spring Bay, N. Y., examination for connecting Lloyds Harbor with … I, 139, 1165
- oldwater River, Miss., examination of … I, 310; III, 1943

Colorado, Department of the, reconnaissances and explorations in .. I, 547:
Colorado River, Ariz., examination of .... I, 4
Columbia, Department of the, reconnaissances and explorations in ... I, 547:
Columbia, District of. *See* District of Columbia.
Columbia River, Oreg. and Wash.:
  Boat railway between The Dalles Rapids and Celilo Falls, construction of .... I, 5
  Cascades Canal, construction of .... I, 5
  Cascades Canal, operating and care of .... I, 5
  Defenses of mouth of .... I.
  Gauging .... I, 5
  Improvement of, above Celilo, Oreg .... I, 51
  Improvement of, at Three Mile Rapids .... I, 5
  Improvement of, below Portland, Oreg .... I, 5
  Improvement of, below Tongue Point, Oreg .... I, 5
  Improvement of, between Rock Island Rapids and Foster Creek Rapids .... I, 517:
  Improvement of, between Vancouver, Wash., and mouth of Willamette River .... I, 5
  Improvement of mouth of .... I, 5
  Wreck below Tongue Point, Oreg., removal of .... I, 5
Compilations:
  Examinations, surveys, projects, appropriations, etc ....
  Laws for maintenance, etc., of navigable waters .... I, 2
Compton Creek, N. J., improvement of .... I.
Conanicut Island, Narragansett Bay, R. I., examination for channel through
Conecuh River, Ala., improvement of .... I, 2
Coney Island Channel, New York Harbor, N. Y., examination of .... I.
Coney Island Creek, N. Y.:
  Bridge at Brooklyn, construction of ....
  Examination of .... I.
Congaree River, S. C., improvement of .... I, 2
Conneaut Harbor, Ohio, improvement of .... I, 4
Connecticut River, Conn., improvement of, below Hartford ....
(*Conover, John B.* schooner), removal of wreck of .... I.
Contentnia Creek, N. C., improvement of .... I, 2
Contingencies, estimate for examinations, surveys, and, of rivers and harbors.
Continuing contracts:
  Allegheny River, Pa., locks and dams .... I, 3
  Boston Harbor, Mass .... I.
  Buffalo Harbor, N. Y .... I, 4
  Chicago River, Ill .... I, 411:
  Christiana River, Del .... I, 1
  Cleveland Harbor, Ohio .... I, 45
  Columbia River, Oreg., Cascades Canal .... I, 50
  Cumberland River above Nashville, Tenn .... I, 344:
  Cumberland Sound, Ga .... I, 2
  Delaware Bay, Del., harbor of refuge .... I, 149:
  Delaware River at Philadelphia, Pa., and Camden, N. J .... I, 144:
  Duluth Harbor, Minn .... I, 3
  Dunkirk Harbor, N. Y .... I, 464:
  Falls of Ohio River at Louisville, Ky .... I, 364:
  Fortifications ....
  Galveston Harbor, Tex .... I, 2
  Grays Harbor and bar entrance, Wash .... I, 5
  Great Lakes, channels in connecting waters of .... I, 435:
  Hudson River, N. Y .... I, 1
  Humboldt Harbor and Bay, Cal .... I, 492:
  Illinois and Mississippi Canal, Ill .... I, 418:
  Indiana Chute, Falls of Ohio River .... I, 364:
  Kentucky River, Ky .... I, 373: III
  Keweenaw Bay to Lake Superior, Mich., waterway from .... I, 3
  Milwaukee, Wis., harbor of refuge .... I, 402:
  Mississippi River, between Missouri River and St. Paul, Minn .... I, 322:
  Mississippi River, between Ohio and Missouri rivers .... I, 318:
  Mississippi River, between Ohio River and Head of Passes .... I, 525:
  Mississippi River, Vicksburg Harbor, Miss .... I, 3
  Missouri River, below Sioux City, Iowa .... I, 527; VI
  Mobile Harbor, Ala .... I, 263; II.
  Monongahela River, W. Va. and Pa .... I, 359; III.

inuing contracts—Continued.
Narragansett Bay, R. I .... I, 74, 908
Newtown Creek, N. Y .... I, 128, 1125
New York Harbor, N. Y., Bay Ridge, Red Hook, and Buttermilk channels........ I, 125, 1117
New York Harbor, N. Y., Newtown Creek........ I, 128, 1125
Northern and Northwestern Lakes, channels in connecting waters of .... I, 435; IV, 2955
Oakland Harbor, Cal........ I, 484; IV, 3327
Ohio River, Dams Nos. 2, 3, 4, 5, and 6 .... I, 356; III, 2358
Ohio River, Falls of, at Louisville, Ky., including Indiana Chute. I, 364; III, 2441
Plaquemine Bayou, La........ I, 282; II, 1759
Point Judith, R. I., harbor of refuge .... I, 77, 918
Portland Harbor, Me., including Back Cove .... I, 37, 790
Providence River, R. I .... I, 74, 908
Rivers and harbors........ I, 22
Rockland Harbor, Me .... I, 33, 783
Sabine Pass, Tex., harbor at........ I, 288; II, 1771
Savannah Harbor, Ga........ I, 224; II, 1493
Superior Harbor, Wis........ I, 386; III, 2592
Superior Lake to Keweenaw Bay, Mich., waterway from........ I, 389; III, 2608
Vicksburg Harbor, Miss........ I, 306; III, 1927
Willamette River above Portland, Oreg........ I, 506; IV, 3129
Wilmington Harbor, Cal .... I, 486; IV, 3335
Wilmington Harbor, Del........ I, 155; II, 1250
Winyah Bay, S. C........ I, 217; II, 1452
Yamhill River, Oreg........ I, 506; IV, 3429
Yaquina Bay, Oreg........ I, 499; IV, 3394
Yazoo River, Miss., mouth of........ I, 306; III, 1927
ntracts, continuing. *See* Continuing contracts.
oper Creek, N. J., improvement of........ I, 152; II, 1223
oper River, S. C., establishment of harbor lines in........ I, 23; II, 1487
osa River, Ga. and Ala.:
Improvement of .... I, 261; II, 1642
Improvement of, between Rome, Ga., and East Tennessee, Virginia and Georgia Railroad Bridge........ I, 261; II, 1642
Improvement of, between Wetumka, Ala., and East Tennessee, Virginia and Georgia Railroad Bridge........ I, 262; II, 1647
Operating and care of locks and dams on........ I, 262; II, 1654
os Bay, Oreg.:
Improvement of entrance and harbor........ I, 496; IV, 3384
Improvement of harbor by dredging........ I, 497; IV, 3387
os River, Oreg., improvement of........ I, 498; IV, 3388
quille River, Oreg.:
Improvement of, between Coquille City and Myrtle Point........ I, 496; IV, 3383
Improvement of mouth........ I, 495; IV, 3380
rporations, occupancy or injury of public structures by........ I, 24, 536; VI, 3981
rps of Engineers:
Changes during the year........ I, 3
Laws of Fifty-fourth Congress, second session, and Fifty-fifth Congress, first session, affecting the .... VI, 4151, 4197
Number and distribution of officers........ I, 3
Officers detached........ I, 4
orpus Christi Channel, Tex., construction of bridge across........ I, 530
os Cob Harbor, Conn., improvement of........ I, 102, 969
ourtableau Bayou, La., improvement of........ I, 283; II, 1762
owlitz River, Wash., improvement of........ I, 520; IV, 3463
rystal River, Fla., examination of........ I, 252; II, 1580
umberland River, Tenn. and Ky.:
Gauging........ I, 23, 309; III, 1936
Improvement of, above Nashville, Tenn .... I, 344; III, 2223
Improvement of, below Nashville, Tenn........ I, 342; III, 2220
Survey of mouth of........ I, 347; III, 2242
umberland Sound, Ga. and Fla.:
Defenses of .... I, 17, 700
Improvement of........ I, 235; II, 1526
urrent River, Ark. and Mo., improvement of........ I, 314; III, 1978
urrituck Sound, N. C., improvement of waterway through .... I, 195; II, 1374
urtis Bay, Md., improvement of channel in Patapsco River to .... I, 173; II, 1306
ut-off, Apalachicola River, Fla., improvement of........ I, 254; II, 1609

Cuyahoga River, Ohio. *See* Cleveland Harbor.
Cypress Bayou, Tex. and La., improvement of .... I, 301;

D.

Dalles Rapids, The, Columbia River, Oreg. and Wash., construction of boat railway to Celilo Falls .... I, 545;
Dams:
  See also Canals.
  Form of water surface backed up by, in running streams ....
D'Arbonne Bayou, La., obstruction of, by raftsmen ....
Darien Harbor, Ga.:
  Improvement of .... I, 229;
  Removal of wreck in .... I, 237;
Davis Island Dam, Ohio River, Pa., operating and care .... I, 356;
Defenses, seacoast. *See* Fortifications.
De Grasse, Sylvia (steamer), removal of wreck of .... I, 502;
Delaware Bay, N. J. and Del.:
  Delaware Breakwater, Del., construction of .... I, 148;
  Harbor of refuge, construction of .... I, 149;
  Pier near Lewes, Del., construction of .... I, 147;
  Waterway to Chincoteague Bay, Va., improvement of .... I, 162;
  Wreck near Ship John Light, removal of ....
Delaware Breakwater, Del., construction of .... I, 148;
Delaware River, N. J., Pa., and Del.:
  Defenses of .... I, 7
  Dike at Fort Mifflin, Pa., rebuilding of ....
  Dike at Woodbury Creek, rebuilding of .... I, 152, 639;
  Marcushook, Pa., improvement of ice harbor at .... I, 146;
  Philadelphia, Pa., improvement above and below .... I, 142;
  Philadelphia, Pa., and Camden, N. J., improvement between .... I, 144;
  Wreck opposite League Island, Pa., removal of .... I, 153;
Delta Cooperage Company, bridge of ....
Delta Point, La., improvement of harbor at, by Mississippi River Commission .... I, 525;
Dennis Creek, N. J., improvement of .... I, 151;
Denton, Md., construction of bridge across Choptank River at ....
Depot, Engineer, Willets Point, N. Y .... I, 6
Des Moines Rapids Canal and Dry Dock, Mississippi River, operating and care of .... I, 323;
Des Moines River, Iowa and Mo., survey of Egyptian Levee, along .... I, 325;
Des Plaines River, Ill., examination of .... I, 421;
Detroit, Mich., reconstruction of bridge across Detroit River, by city of ....
Detroit River, Mich.:
  Bridge at Detroit, reconstruction of ....
  Improvement of .... I, 449;
Dexter, N. Y., examination of Black River to harbor at .... I, 482;
District of Columbia:
  See also Washington, D. C.
  Public buildings and grounds and Washington Monument .... I, 542; VI, 40
  Washington Aqueduct, increasing water supply of city of Washington .... I, 540; VI
  Washington Aqueduct, maintenance and repair of .... I, 537; VI
  Washington Aqueduct, raising height of Great Falls Dam .... I, 540;
Dividing Creek, Md. *See* La Trappe River.
Dividing Creek, N. J., examination of .... I, 154; II
Division engineers ....
Divisions, engineer ....
Doboy Bar, Ga., survey of .... I, 237; II
Dog River, Miss., survey of .... I, 276;
Dredge boats on Upper Mississippi River, operation of .... I, 23, 321; III
Duck Creek, Del. *See* Smyrna River.
Duck Island Harbor, Conn., construction of harbor of refuge at .... I, 8
Duluth, Minn.:
  Bridge across St. Louis River to Superior, Wis., construction of ....
  Harbor lines at, modification of .... I, 23; III
  Improvement of harbor at .... I, 386; III
  Improvement of channels in connecting waters of Great Lakes between Buffalo, Chicago, and .... I, 435;
Duluth Street Railway Company, bridge of ....

kirk Harbor, N. Y., improvement of.......... I, 464; IV, 3103
amish River, Wash., improvement of.......... I, 511; IV, 3438
bury Beach, Mass. *See* Duxbury Harbor.
bury Harbor, Mass.:
Examination of.......... I, 63, 860
Examination of Duxbury Beach.......... I, 64, 862

E.

s, James B., improvement of South Pass, Mississippi River, by representatives of.......... I, 25, 277; II, 1731
t Chester Creek, N. Y.:
  Examination of.......... I, 140, 1175
  Improvement of.......... I, 118, 1089
tern Branch, Elizabeth River, Va. *See* Elizabeth River.
t River, Ga. *See* Brunswick Harbor.
t River, N. Y.:
  Bridge at New York City, construction of.......... I, 532
  Examination of Wallabout Channel.......... I, 115, 1047
  Harbor lines at New York City, establishment of.......... I, 23, 1081
  Improvement of.......... I, 111, 1026
st River, Wis., construction of bridge across, at Green Bay.......... I, 532
st River Bridge Company, bridge of.......... I, 532
gartown, Marthas Vineyard, Mass., improvement of inner harbor at.... I, 68, 890
gewater, N. J., removal of wreck in Hudson River, below.......... I, 114, 1040
yptian Levee, Des Moines River, Iowa and Mo., survey of.......... I, 325; III, 2124
izabeth River, N. J.:
  Improvement of.......... I, 131, 1134
  Survey of.......... I, 141, 1185
izabeth River, Va.:
  Bridge across Southern Branch at Norfolk, construction of.......... I, 533
  Norfolk Harbor and its approaches, improvement of.......... I, 190; II, 1353
  Waterway to Albemarle Sound, N. C., improvement of.......... I, 195; II, 1374
  Western Branch, improvement of.......... I, 191; II, 1365
  Wreck in Southern Branch, removal of.......... I, 198; II, 1380
lk River, W. Va., improvement of.......... I, 380; III, 2565
lliott Bay, Wash., improvement of waterway via.......... I, 513; IV, 3445
llis Island, New York Harbor, N. Y., modification of harbor lines at.......I, 23, 1075
llsworth, Me., examination of Union River near.......... I, 42, 800
mbankments.......... I, 8
mory River, Tenn., survey of, up to Harriman.......... I, 354; III, 2316
mplacements. *See* Fortifications.
mployees injured while engaged upon public works, necessity of legislation for relief of.......... I, 25
ngineer Depot, Willets Point, N. Y.......... I, 6, 22, 574
ngineer divisions.......... I, 25
ngineers, Battalion of.......... I, 6, 22, 570
ngineer School, Willets Point, N. Y.......... I, 5, 22, 562
Engineers, Corps of. *See* Corps of Engineers.
Engineers, division.......... I, 25
Engineers, Office of the Chief of.......... I, 550
Engineers, The Board of.......... I, 4, 553
Enterprise (schooner), removal of wreck of.......... I, 80, 927
Erie Basin, Black Rock Harbor, N. Y., survey of Buffalo entrance to.. I, 473; IV, 3245
Erie Canal, N. Y.:
  Preservation of bench marks along.......... I, 546; VI, 4122
  Widening locks of, to permit passage of war vessels.......... I, 473; IV, 3250
Erie Harbor, Pa.:
  Harbor lines in Presque Isle Bay, establishment of.......... I, 24; IV, 3265
  Improvement of.......... I, 463; IV, 3097
  Survey of.......... I, 473; IV, 3237
  Water levels.......... I, 547; VI, 4127, 4128
  Wrecks in, removal of.......... I, 472
Erie Lake:
  See also Northern and Northwestern Lakes.
  Defenses on.......... I, 7, 20
  Examination of shoals in.......... I, 547; VI, 4123
  Water levels.......... I, 547; VI, 4127, 4128
Escambia River, Fla., improvement of.......... I, 259; II, 1631

Escanaba, Mich., water levels at.......................... I, 547; VI, 412,

Esopus Creek, N. Y. *See* **Saugerties Harbor.**

Essex County, Mass., bridge of.......................... I

Essex River, Mass., improvement of.......................... I, 4

Estimates:

  California Débris Commission.......................... I

  Engineer Depot, Willets Point, N. Y.......................... I

  Fortifications..........................

  Mississippi River Commission.......................... I

  Missouri River Commission.......................... I

  New York Harbor, N. Y., supervision of.......................... I

  Northern and Northwestern Lakes.......................... I

  Public buildings and grounds, and Washington Monument, D. C.......... I

  Rivers and harbors, examinations, surveys, etc., of.......................... I

  Rivers and harbors, improvement of.......................... I

  Surveys and reconnaissances in military departments, and for maps.... I

  Washington Aqueduct, D. C., maintenance and repair of.......................... I

  Washington Monument, D. C., care and maintenance of.......................... I

Eureka Harbor, Cal., examination of.......................... I, 494; IV,

Everett Harbor, Wash., improvement of.......................... I, 515; IV, 5

Examinations:

  Compilation relative to surveys and.......................... I

  Estimate for surveys, contingencies, and, of rivers and harbors.......... I

Exeter River, N. H., survey of, from mouth to upper bridge in Exeter...... I, 4

Explorations and reconnaissances in military departments.......... I, 547, VI, 4

F.

Fairhaven Harbor, Mass. *See* **New Bedford Harbor.**

Fairport Harbor, Ohio, improvement of.......................... I, 459; IV,

Falia, Bogue, La., improvement of.......................... I, 278; II, 1

Fall River Harbor, Mass., survey of.......................... I, 81

Falls of Ohio River, Louisville, Ky., improvement of.......... I, 364; III, 2

Far Rockaway, N. Y., examination of channels to Inwood and.......... I, 140, 11

Feather River, Cal.:

  Improvement of.......................... I, 490; IV,

  Improvement of, by California Débris Commission.......... I, 528; VI, 3

Fernandina, Fla., improvement of waterway to Savannah, Ga.......... I, 236; *II, 1*

Fishing Creek, N. C., improvement of.......................... I, 200; II, 1

Fish Island, New Bedford Harbor, Mass. *See* **New Bedford Harbor.**

Five Mile Creek, Ala.:

  Examination for canal to Black Warrior River.......... I, 275; II, 17

  Survey for canal to Black Warrior River.......... I, 275; II, 17

Five Mile River Harbor, Conn., improvement of.......................... I, 100, 9

Flag Lake and River, Wis. *See* **Portwing Harbor.**

Flathead River, Mont., improvement of.......................... I, 522; IV, 34

Flint River, Ga., improvement of.......................... I, 255; II, *16*

Florida:

  Defenses of coast of.......................... I, 7, 17, 18, 702, 71

  Obstruction of navigable waters in, by the water hyacinth.......... I, 2

Flushing Bay, N. Y.:

  Examination of channel connecting Newtown Creek and.......... I, 139, 115

  Improvement of.......................... I, 123, 110

Forked Deer River, Tenn.:

  Improvement of.......................... I, 340, 341; III, 221

  Survey of.......................... I, 347; III, 223

Fort Hamilton, New York Harbor, N. Y., removal of wreck below........ I, *114*, 1069

Fortifications:

  Appropriations.......................... I, 8

  Continuing contracts.......................... I, 9

  Estimates.......................... I, 2

  New works.......................... I, 8

  Preservation and repair of.......................... I,

  Projects.......................... I, 7, 53

  Sea walls and embankments.......................... I, 8

  Sites for, acquisition of.......................... I, 7

  Submarine mines.......................... I, 11

Fort McHenry, Baltimore Harbor, Md.:

  Removal of wreck off.......................... I, 174; *II, 1307*

  Sea wall at.......................... I, 15, 639

Iarion, Fla., preservation and repair of.......... I, 17, 702
Iifflin, Pa., rebuilding dike at.......... I, 638
Ionroe, Va., sewerage system at.......... I, 16, 663
Iontgomery, N. Y., preservation and repair of.......... I, 744
Iiagara, N. Y., sea wall at.......... I, 20, 743
chuyler, N. Y., sea wall at.......... I, 611
mith, Ark.:
nprovement of Arkansas River at.......... I, 311; III, 1952
rvey of Arkansas River at.......... I, 316; III, 1989
iver, Wis.:
ridge across United States canal at Appleton, construction of.......... I, 532
ridge at Green Bay, construction of.......... I, 532
ridge at Menasha, construction of.......... I, 533
nprovement of.......... I, 406; IV, 2709
nprovement of Green Bay Harbor.......... I, 395; IV, 2657
perating and care of locks and dams on.......... I, 407; IV, 2719
fort, Me., examination for removal of wreck in Marsh River.......... I, 43, 801
fort, Mich., improvement of harbor at.......... I, 432; IV, 2939
ricka, Marie (ship), removal of wreck of, from Man of War Harbor, Key West, Fla.......... I, 251; II, 1566
h Broad River, Tenn.:
mprovement of.......... I, 352; III, 2308
njury to training walls.......... VI, 3983
d, Lottie K. (schooner), removal of wreck of.......... II, 1227
n, Ark.:
mprovement of Red River above.......... I, 300; III, 1895
mprovement of Red River below.......... I, 299; III, 1877

G.

na River, Ill., operating and care of lock and dam on.......... I, 323; III, 2109
eston and Brazos Canal, Tex., examination of.......... I, 298; II, 1809
eston and Brazos Navigation Company, examination of canal of. I, 298; II, 1809
eston Bay and Harbor, Tex.:
Galveston Bay, examination of channel to Brazos River.......... I, 298; II, 1809
Galveston Bay, improvement of ship channel in.......... I, 294; II, 1803
Galveston Harbor, defenses of.......... I, 7, 19, 737
Galveston Harbor, improvement of.......... I, 292; II, 1793
Galveston Island, survey at easterly end of.......... I, 298; II, 1813
Morgan Canal, operating and care of.......... I, 298; II, 1808
Morgan Cut and Canal, improvement of.......... I, 294; II, 1803
West Galveston Bay, improvement of channel in.......... I, 295; II, 1804
eston Island, Tex., survey at easterly end of.......... I, 298; II, 1813
onade River, Mo., improvement of, by Missouri River Commission. I, 527; VI, 3837
ging:
See also Hydraulics.
Columbia River, Oreg. and Wash.......... I, 507; IV, 3432
Mississippi River and tributaries.......... I, 23, 309; III, 1936
Mississippi River at St. Paul, Minn.......... I, 332; III, 2164
Northern and Northwestern Lakes.......... I, 547; VI, 4127
ley River, W. Va., improvement of.......... I, 380; III, 2564
ney Channel, New York Harbor, N. Y.:
Improvement of.......... I, 113; 1031
Removal of wreck in.......... I, 114; 1039
esee River, N. Y. *See* Charlotte Harbor.
rge Lake, St. Johns River, Fla. *See* Volusia Bar.
rges River, Me., improvement of.......... I, 35, 785
rgetown, D. C. *See* Washington.
rgia, defenses of coast of.......... I, 7, 17, 700
ncove Harbor, N. Y., improvement of.......... I, 122, 1103
ucester Harbor, Mass., improvement of.......... I, 49, 835
hen Creek, N. J., improvement of.......... I, 153; II, 1225
ernor Marvin (steamer), removal of wreck of.......... I, 251; II, 1566
ernors Island, New York Harbor, N. Y., survey of channel between the Battery and.......... I, 141, 1182
vanus Bay channels, New York Harbor, N. Y.:
Improvement of.......... I, 125, 1117
Survey of.......... I, 140, 1177
vanus Canal, New York Harbor, N. Y.:
Improvement of.......... I, 125, 1118
Removal of wreck in.......... I, 138, 1158

Gowanus Creek, New York Harbor, N. Y.:
  Improvement of channel in .... I, 12
  Survey of .... I, 14
Grand Haven Harbor, Mich., improvement of .... I, 427; IV
Grand Lake, La., improvement of .... I, 285; II
Grand Marais, Mich., improvement of harbor of refuge at .... I, 392; III
Grand Marais, Minn., improvement of harbor at .... I, 385; III
Grand Rapids, Wabash River, Ind. and Ill., operating and care of lock and dam at .... I, 368; III
Grand River, La., improvement of .... I, 282; II
Grand River, Mich.:
  Improvement of .... I, 428; IV
  Improvement of Grand Haven Harbor .... I, 427; IV
Grand River, Ohio. *See* **Fairport Harbor.**
Grasse, Sylvia de **(steamer), removal of wreck of** .... I, 502; IV
Grays Harbor, Wash., improvement of, and bar entrance .... I, 509; I
Great Egg Harbor Inlet, N. J., removal of wrecks in .... I, 153; II
Great Falls Dam, Potomac River, raising height of .... I, 540; VI
Great Harbor, Woods Hole, Mass. *See* **Woods Hole Channel.**
Great Kanawha River, W. Va.:
  Improvement of .... I, 381; III
  Injury to works, and unlawful deposits in V
  Operating and care of locks and dams on .... I, 383; III
Great Lakes:
  Defenses of ports in New York .... I, 7
  Examination for ship canal to Hudson River .... I, 472; II
  Improvement of channels in connecting waters of .... I, 435; IV
  Surveys, and correcting, printing, and issuing of charts .... I, 544; V
  Water levels .... I, 547; VI
Great Pedee River, S. C., improvement of .... I, 216; II
Great Salt Pond, Block Island, R. I., improvement of .... I, 7
Great Sodus Bay, N. Y.:
  Improvement of harbor at .... I, 475; IV
  Use and occupancy of pier VI
Green Bay, Mich., water levels at Escanaba .... I, 547; VI, 412
Green Bay, city of, Wis.:
  Construction of bridges across East and Fox rivers, by ....
  Improvement of harbor at .... I, 395; IV
Green Jacket Shoal, Providence River, R. I., removal of .... I, 7
Green River, Ky.:
  Improvement of, above mouth of Big Barren River (Lock and Dam No. 5) .... I, 370; III
  Operating and care of locks and dams on .... I, 370; III
  Reconstruction of Lock No. 2, at Rumsey .... I, 369; III
  Survey at mouth of, for new lock and dam .... I, 373; III
Greenville Harbor, Miss., improvement of, by Mississippi River Commission .... I, 525; V
Greenwich Harbor, Conn., improvement of .... I, 1
Grossetete Bayou, La., examination of .... I, 292; II
Gulfport, Miss., examinations for channel to Ship Island Harbor and Gulf of Mexico .... I, 276; II
Gulf States, obstruction of navigable waters in, by the water hyacinth ....
Gull Lake, Minn., construction of reservoir at .... I, 326; III
Guns. *See* **Fortifications.**
Gurnet Rock, Plymouth Harbor, Mass., examination of .... I, 6
Guyandotte River, W. Va., improvement of .... I, 378; III

H.

Hagen, Rose **(barge), removal of wreck of** .... I, 171; II
Hamilton, Fort, New York Harbor, N. Y., removal of wreck below .... I, 114
Hampton Roads, Va.:
  Defenses of .... I, 7, 16
  Removal of wrecks in .... I, 198; II
Harbor lines, establishment of ....
  Allouez Bay, Wis .... I, 23; III
  Ashley River, S. C .... I, 23; II
  Boston Harbor, Mass .... I, 23
  Bridgeport, Conn .... I, 23
  Cambridge, Mass .... I, 23

or lines, establishment of—Continued.
harles River at Cambridge, Mass .... I, 23, 881
harleston Harbor, S. C .... I, 23; II, 1487
ooper River, S. C .... I, 23; II, 1487
uluth Harbor, Minn .... I, 23; III, 2647
ast River at New York, N. Y .... I, 23, 1081
llis Island, New York Harbor, N. Y .... I, 23, 1075
rie Harbor, Pa .... I, 24; IV, 3265
arlem River, N. Y .... I, 23, 1077
udson River at New York, N. Y .... I, 23, 1067, 1070
ewaunee Harbor, Wis .... I, 24; IV, 2785
ew York Harbor, N. Y .... I, 23, 1067, 1070, 1075, 1077, 1081
lympia Harbor, Wash .... I, 24; IV, 3484
puyten Duyvil Creek, N. Y .... I, 23, 1077
uperior Bay, Minn. and Wis .... I, 23; III, 2647
uperior Harbor, Wis .... I, 23; III, 2647
aukegan Harbor, Ill .... I, 24; IV, 2786
ors and rivers. *See* Rivers and harbors.
em River, N. Y.:
ridge obstructing, at New York City .... I, 536
ridges across, location and characteristics of .... I, 1024
arbor lines at New York City, modification of .... I, 23, 1077
mprovement of .... I, 110, 1019
owe River, N. C., improvement of waterway via .... I, 204; II, 1395
aseeket River, Me., survey of .... I, 44, 815
ford, Conn., improvement of Connecticut River below .... I, 86, 948
Slough, Wash., improvement of .... I, 511; IV, 3438
e de Grace, Md., improvement of Susquehanna River above and be-
w .... I, 163; II, 1272
Lake Channel, St. Marys River, Mich., improvement of .... I, 439; IV, 3006
es, John C. (schooner), removal of wreck of .... I, 198; II, 1379
na Harbor, Ark., improvement of, by Mississippi River Commission. I, 525; V, 3505
Gate, East River, N. Y., improvement of .... I, 111, 1026
pstead, N. Y.:
ee also Glencove Harbor.
onstruction of bridge across Long Beach Channel, by town of .... I, 533
lerson Harbor, N. Y., removal of wreck in .... I, 482; IV, 3304
Island, Allegheny River, Pa., construction of lock and dam at. I, 363; III, 2428
brandt Bayou, Tex., construction of bridge across .... I, 533
boro Bay, Fla., examination of .... I, 252; II, 1574
boro River, Fla.:
xamination of, up to Tampa .... I, 252; II, 1574
emoval of wreck in, at Tampa .... I, 251; II, 1566
nsburg, N. Y., construction of bridge across St. Lawrence River near. I, 531
and (Black Lake) Harbor, Mich.:
mprovement of .... I, 426; IV, 2916
urvey of .... I, 435; IV, 2950
ay, L. (schooner), removal of wreck of .... I, 42, 798
ochitto River, Miss., examination of .... I, 291; II, 1777
Island Pass and Harbor, Miss.:
mprovement of Horn Island Pass .... I, 270; II, 1693
urvey of .... I, 276; II, 1716
e, William (tug), removal of wreck of .... I, 138, 1158
atonic River, Conn.:
mprovement of .... I, 92, 956
urvey of .... I, 105, 979
ton, East and West Texas Railway Company, bridge of .... I, 534
on River, N. Y. and N. J.:
xamination for ship canal to Great Lakes .... I, 472; IV, 3128
xamination of Nyack Harbor, N. Y .... I, 115, 1044
arbor lines at New York, N. Y., modification of .... I, 23, 1067, 1070
mprovement of, between Coxsackie and Troy, N. Y .... I, 105, 996
mprovement of Peekskill Harbor, N. Y .... I, 109, 1016
Wrecks at Jersey City and Edgewater, N. J., removal of .... I, 114, 1039, 1040
boldt Harbor and Bay, Cal.:
Examination of Eureka Harbor .... I, 494; IV, 3377
mprovement of .... I, 492: IV, 3366
tington Harbor, N. Y., improvement of .... I, 121, 1100
n Harbor, Ohio, improvement of .... I, 455; IV, 3064

Huron Lake:
  See also Northern and Northwestern Lakes.
  Improvement of harbor of refuge at Sand Beach, Mich........... I, 444; IV
  Water levels.. I, 547; V
Huron River, Mich., examination of................................ I, 451;
Hyacinth, water, obstruction of navigable Southern rivers by the..........
Hyannis, Mass., improvement of harbor of refuge at.............................. I,
Hydraulic mining in California. *See* California Débris Commission.
Hydraulics:
  See also Gauging.
  Form of water surface backed up by dams in running streams.......... II

I.

Iberville Parish, La., bridge of..
Illinois and Mississippi Canal, Ill.:
  Construction of.. I, 418;
  Operating and care of canal around rapids of Rock River....... I, 420;
Illinois River, Ill.:
  Examination of.. I, 421;
  Improvement of.. I, 415;
  Operating and care of Lagrange and Kampsville locks and dams. I, 417;
Indiana Chute, Falls of Ohio River, Louisville, Ky., improvement of. I, 364;
Indian River, Fla., improvement of.................................. I, 242;
Indian River Bay, Del., improvement of waterway via................ I, 162;
Indian River Inlet, Fla. *See* Indian River.
Individuals, occupancy or injury of public structures by.......... I, 24, 536;
Injury to structures built by the United States.................. I, 24, 536;
Inland waterways. *See* Waterways.
Inner Beach, Hempstead, N. Y., construction of bridge to Barnum Island..
Inside routes. *See* Waterways.
Internal waterways. *See* Waterways.
Inwood, N. Y., examination of channels to Far Rockaway and............ I, 1
Isle of Wight Bay, Md., improvement of waterway via................ I, 162;

J.

Jackson, Andrew (barge), removal of wreck of............................ I, 11
James River, Va.:
  Improvement of.. I, 187; II
  Protection of Jamestown Island............................ I, 189; II
Jamestown Island, James River, Va., protection of................. I, 189; II
Jeanerette, La., construction of bridge across Bayou Teche, by town of....
Jefferson County, Tex., bridge of...
Jennings, Mont., survey of Kootenai River above.................. I, 523;
Jersey City, N. J., removal of wreck in Hudson River at................ I, 11
Johnson, Hager (canal boat), removal of wreck of...................... I, 11
Judith, Point, R. I.:
  Construction of harbor of refuge at...................................... I,
  Improvement of entrance to Point Judith Pond............................ I,
  Survey of easterly breakwater to shore..................................... I,
Jupiter Inlet, Fla.:
  Examination of.. I, 251; II
  Improvement of.. I, 242; II

K.

Kalamazoo River, Mich.:
  Improvement of.. I, 426; IV
  Improvement of Saugatuck Harbor........................... I, 425; IV
Kampsville Lock and Dam, Illinois River, Ill., operating and care of. I, 417; IV
Kansas City, Osceola and Southern Railway Company, bridge of...........
Kansas City, Shreveport and Gulf Railway Company, bridge of.............
Kenduskeag River, Me., survey of mouth of................................ I, 44
Kennebec River, Me.:
  Defenses of.. I,
  Improvement of.. I,
Kennedy, Margaret (schooner), removal of wreck of................ I, 174; II
Kenosha Harbor, Wis.:
  Improvement of.. I, 404; IV
  Survey of... I, 409; IV
  Use and occupancy of south pier.. VI

ucky River, Ky.:
mprovement of.. I, 373; III, 2513
perating and care of locks and dams on.......................... I, 375; III, 2519
unee Harbor, Wis.:
arbor lines at, establishment of............................... I, 24; IV, 2785
mprovement of.. I, 399; IV, 2675
enaw Bay, Mich., improvement and operating and care of waterway to
  Lake Superior .... I, 389, 390; III, 2608
enaw Point, Mich., waterway across. *See* Keweenaw Bay.
ort Harbor, N. J., improvement of .... I, 135, 1147
West Harbor, Fla.:
efenses at .... I, 7, 17, 703
mprovement of northwest entrance of............................ I, 244; II, 1555
Vrecks in Man of War Harbor, removal of .... I, 251; II, 1566
ston, Tenn., construction of bridge across Clinch River at............. I, 530
ickinick River, Wis., construction of bridges across, at Milwaukee.... I, 533
ry, Me., construction of bridges to Badgers Island and York........... I, 534
enai River, Idaho and Mont.:
mprovement of, between Bonners Ferry, and international boundary .... I, 521; IV, 3467
urvey of, above Jennings, Mont .... I, 523; IV, 3482

L.

rosse Harbor, Wis.:
mprovement of .... I, 322; III, 2059
urvey of... I, 325; III, 2116
urche Bayou, La., improvement of .... I, 281; II, 1757
ange Lock and Dam, Illinois River, Ill., operating and care of.. I, 417; IV, 2822
Charles, La., construction of bridge across Calcasieu River at........ I, 531
City, Ark., construction of bridge across Lake St. Francis near...... I, 531
s, Great. *See* Northern and Northwestern Lakes.
Shore and Michigan Southern Railway Company:
ridge of, at Ashtabula, Ohio.. I, 534
ridge of, at Toledo, Ohio .... I, 531
s, Northern and Northwestern. *See* Northern and Northwestern Lakes.
rappe River, Md.:
mprovement of .... I, 165; II, 1276
urvey of... I, 171; II, 1295
ie, *Annie* (tug), removal of wreck of................................ I, 472
s:
ompilation of, for maintenance of navigable waters............. I, 24; VI, 4137
ifty-fourth Congress, second session, and Fifty-fifth Congress, first session, affecting Corps of Engineers................................ VI, 4151, 4197
ecessity of, for relief of injured employees on public works........... I, 25
River, Miss., improvement of.................................... I, 272; II, 1697
ue Island, Pa., removal of wreck in Delaware River opposite .... I, 153; II, 1227
h Lake, Minn.:
perating and care of reservoir at.............................. I, 328; III, 2142
eservoir at .... I, 326; III, 2137
slation. *See* Laws.
on Creek, Staten Island, N. Y. *See* Staten Island—New Jersey channel.
rt, J. B., bridge of .... I, 534
sa Fork, Big Sandy River, Ky., improvement of.................. I, 376; III, 2529
es, Del.:
onstruction of iron pier in Delaware Bay, near................. I, 147; II, 1213
mprovement of waterway from Chincoteague Bay, Va., to Delaware
  Bay, near.. I, 162; II, 1270
s River, Wash.:
xamination of North Fork, to head of navigation................ I, 523; IV, 3469
urvey of, up to Lacenter....................................... I, 523; IV, 3473
itt, *Henry* (schooner), removal of wreck of .... I, 198; II, 1379
e Assawaman Bay, Del., improvement of waterway via............. I, 162; II, 1270
e Harbor, Mass. *See* Woods Hole Channel.
e Harbor, N. H., improvement of harbor of refuge at.................. I, 41, 796
e Kanawha River, W. Va.:
mprovement of.. I, 384; III, 2582
perating and care of lock and dam on........................... I, 384; III, 2582
e Pedee River, S. C., improvement of............................ I, 215; II, 1444
e Pigeon River, Tenn., improvement of.......................... I, 352; III, 2310

Little River, La., between Scopini Cut-off and Knox Point. *See* Red River, below Fulton, Ark.
Little Rock, Ark.:
  Improvement of Arkansas River at........ I, 311; III, 1
  Survey of Arkansas River at........ I, 316; III, 1
Little Sodus Bay, N. Y., improvement of harbor at........ I, 475; IV,
Lloyds Harbor, N. Y., examination for connecting Cold Spring Bay with.... I, 139, 1
Locks. *See* Canals.
Lockwoods Folly River, N. C., improvement of........ I, 211; II, 1
Long Beach Channel, Hempstead Harbor, N. Y., construction of bridge across. I,
Long Island, N. Y., defenses at........ I, 7, 14,
Long Island City, N. Y., alteration of bridge across Newtown Creek at..... I,
Long Island Sound, defenses of eastern entrance to........ I, 7, 13,
Lookout, Cape, harbor of refuge, N. C., survey of........ I, 212; II, 1
Lorain, Ohio, improvement of Black River at........ I, 457; IV, 3
Louisiana, obstruction of navigable waters in, by the water hyacinth...... I,
Louisville, Ky.:
  Improvement of Falls of Ohio River, including Indiana Chute.. I, 364; III, 2
  Operating and care of Louisville and Portland Canal........ I, 366; III, 2
Louisville and Portland Canal, Ky., operating and care of........ I, 366; III, 2
Loutre, Pass a, Mississippi River, closing crevasse in........ I, 291; II, 1
Lower Chipola River, Fla., improvement of........ I, 254; II, 1
Lower Machodoc Creek, Va., improvement of........ I, 181; II, 1
Lubec Channel, Me., improvement of........ I, 26,
Ludington Harbor, Mich.:
  Improvement of........ I, 430; IV, 2
  Survey of........ I, 435; IV, 2
Lumber River, N. C. and S. C., improvement of........ I, 214; II, 1
Lumberton Branch, Rancocas River, N. J. *See* Rancocas River.
Lynn Harbor, Mass.:
  Improvement of........ I, 52,
  Survey of........ I, 65,

M.

McHenry, Fort, Baltimore Harbor, Md.:
  Removal of wreck off........ I, 174; II, 1
  Sea wall at........ I, 15,
Machias River, Me., survey of, from Machias to Machiasport........ I, 43,
Machodoc (Lower) Creek, Va., improvement of........ I, 181; II, 1
Maçon Bayou, La., improvement of........ I, 304; III, 1
Maine, defenses of coast of........ I, 7, 11,
Main ship channel, New York Harbor, N. Y., improvement of........ I, 113, 1
Maintenance, operating, and care of certain public works, provision for.... I
Malden River, Mass., improvement of........ I, 53,
Mamaroneck Harbor, N. Y., improvement of........ I, 117, 1
Manasquan, N. J., construction of bridge across Manasquan River at........ I,
Manasquan River, N. J., construction of bridge across, at Manasquan........ I,
Manatee River, Fla., improvement of........ I, 248; II, 1
Manchac Bayou, La., improvement of........ I, 280; II, 1
Manchester Harbor, Mass.:
  Improvement of........ I, 51,
  Survey of........ I, 64, 65, 866,
Manistee Harbor, Mich., improvement of........ I, 431; IV, 2
Manitowoc Harbor, Wis.:
  Construction of city bridge across Manitowoc River........ I,
  Improvement of........ I, 400; IV, 2
Manitowoc River, Wis. *See* Manitowoc Harbor.
Man of War Harbor, Key West, Fla., removal of wrecks in........ I, 251; II, 1
Manokin River, Md., improvement of........ I, 168; II, 1
Maps:
  Charts, Northern and Northwestern Lakes........ I, 544; VI, 4
  Estimates for publication of military and other........ I, 5
  Printing and distribution of, by Office of the Chief of Engineers........ I, 5
Marblehead Harbor, Mass., survey of........ I, 65,
Marcelo (bark), removal of wreck of, from Man of War Harbor, Key West, Fla........ I, 251; II, 1
Marcushook, Pa., improvement of ice harbor in Delaware River at... I, 146; II, 1
Mare Island Strait, Cal., survey of........ I, 488; IV, 3
Marianna, Tex., construction of bridge across Trinity River above........ I,

Fredericka (ship), removal of wreck of, from Man of War Harbor, Key West, Fla........ I, 251; II, 1566
n County, Miss., bridge of........ I, 530
n, Fort, Fla., preservation and repair of........ I, 17, 702
uette Bay, Mich. *See* Marquette Harbor.
uette Harbor, Mich.:
  onstruction of harbor of refuge at Presque Ile Point........ I, 391; III, 2638
  mprovement of........ I, 391; III, 2615
  Vater levels........ I, 547; VI, 4127, 4129
n River, Me., examination for removal of wreck at Frankfort........ I, 43, 801
has Vineyard, Mass., improvement of inner harbor at Edgartown........ I, 68, 890
in, *Governor* (steamer), removal of wreck of........ I, 251; II, 1566
achusetts, defenses of southeast coast of........ I, 7, 12, 603
aponi River, Va., improvement of........ I, 185; II, 1342
awan Creek, N. J.:
  mprovement of........ I, 134, 1145
  mprovement of Keyport Harbor........ I, 135, 1147
ituck Harbor, N. Y., improvement of........ I, 119, 1096
nee Bay and River, Ohio. *See* Toledo Harbor.
phis Harbor, Tenn., improvement of, by Mississippi River Commission........ I, 525; V, 3505
sha, Wis., construction of bridge across Fox River, by city of........ I, 533
minee Harbor, Mich. and Wis.:
  mprovement of........ I, 393; IV, 2650
  Survey of........ I, 408; IV, 2751
minee River, Mich. and Wis., improvement of........ I, 393; IV, 2652
nentau River, La., improvement of, and tributaries........ I, 285; II, 1767
imac River, Mass.:
  Dredging between Newburyport and Haverhill, estimate of cost of........ I, 64, 865
  Improvement of........ I, 46, 827
  Improvement of Newburyport Harbor........ I, 45, 824
us River, Conn., improvement of........ I, 102, 969
igan City Harbor, Ind., improvement of........ I, 421; IV, 2895
igan Lake:
  See also Northern and Northwestern Lakes.
  Construction of harbor of refuge at eastern entrance of canal between Sturgeon Bay and........ I, 397; IV, 2671
  Examination of Illinois and Des Plaines rivers, Ill., for extension of navigation to........ I, 421; IV, 2882
  Improvement of canal to Sturgeon Bay, Wis........ I, 396; IV, 2660
  Operating and care of canal to Sturgeon Bay, Wis........ I, 397; IV, 2666
  Survey of Wolf Lake and River, Ill. and Ind., with reference to their navigation in connection with........ I, 421; IV, 2887
  Water levels........ I, 547; VI, 4127, 4129
dle Fork, Forked Deer River, Tenn.:
  Improvement of........ I, 340, 341; III, 2217
  Survey of........ I, 347; III, 2234
lin, Fort, Pa., rebuilding dike at........ I, 638
lin Township, Pa.:
  Construction of bridge across Monongahela River to Braddock Township. I, 530
  Construction of bridge across Monongahela River to Port Perry........ I, 529
n, Ill., operating and care of canal around rapids of Rock River at........ I, 420; IV, 2880
itary departments, reconnaissances and explorations in........ I, 547; VI, 4131
lbridge, Me., removal of wreck in Narraguagus Bay at........ I, 42, 798
le Lacs Lake, Minn., examination of, for reservoir........ I, 332; III, 2170
l Neck Creek Inlet, N. Y., construction of bridge across, at Bayville........ I, 533
l River, Conn. *See* New Haven Harbor.
waukee, Wis.:
  Bridges across Kinnickinick River, construction of........ I, 533
  Harbor of refuge in Milwaukee Bay, construction of........ I, 402; IV, 2689
  Improvement of harbor at........ I, 403; IV, 2692
  Survey of harbor at........ I, 408; IV, 2765
  Water levels........ I, 547; VI, 4127, 4129
  Wreck in Milwaukee Bay, removal of........ I, 407; IV, 2751
waukee River and Bay, Wis. *See* Milwaukee.
nes, submarine........ I, 11
ngo Creek, S. C., improvement of........ I, 217; II, 1450
ning, hydraulic, in California. *See* California Débris Commission.

Minnesota River, Minn., improvement of [illegible]
Mississippi River, etc.:
  Examination of [illegible]
  Improvement of [illegible]
M[illegible] construction [illegible]
[illegible] survey [illegible]
Mississippi River:
  [illegible] Cannon River, survey from [illegible]
  [illegible] improvement [illegible] River [illegible]
  [illegible] survey from [illegible]
  [illegible] survey from [illegible]
  [illegible] improvement by Mississippi River Commission [illegible]
  [illegible] Lock, operating and care of [illegible]
  [illegible] survey from [illegible]
  [illegible] mouth of [illegible] River, Iowa, survey from [illegible]
  [illegible]
  [illegible] at or near St. Paul, Minn. [illegible]
  [illegible] improvement by Mississippi River Commission [illegible]
  [illegible] to Lagrange, Mo., survey from [illegible]
  Head of [illegible] to head waters, survey from [illegible]
  Head of [illegible] improvement, surveys, etc. [illegible]
  Helena Harbor, Ark., improvement by Mississippi River Commission [illegible]
  [illegible] to Muscatine, Iowa, survey from [illegible]
  [illegible] survey of [illegible]
  Lagrange [illegible] Mo., survey from [illegible]
  Lock and Dam No. 2 between St. Paul and Minneapolis, construction of [illegible]
  L[illegible] in [illegible]
  Memphis Harbor, Tenn., improvement by Mississippi River Commission [illegible]
  Minneapolis, Minn., to Missouri River, improvement from [illegible]
  Minneapolis, Minn., to St. Paul, construction of Lock and Dam No. 2 [illegible]
  Missouri River to Minneapolis, Minn., improvement from [illegible]
  Missouri River to Ohio River, improvement from [illegible]
  Natchez Harbor, Miss., improvement by Mississippi River Commission 1,[illegible]
  Muscatine to Iowa River, Iowa, survey from 1,[illegible]
  New Boston to [illegible] Landing, Ill., survey from 1,[illegible]
  New Madrid Harbor, Mo., improvement by Mississippi River Commission [illegible]
  New Orleans Harbor, La., defenses of [illegible]
  New Orleans Harbor, La., improvement by Mississippi River Commission 1,[illegible]
  Ohio River to Head of Passes, improvement, surveys, etc. 1,[illegible]
  Ohio River to Missouri River, improvement from 1,[illegible]
  Oquawka to [illegible], Ill., survey from 1,[illegible]
  Pass a Loutre [illegible] in 1,[illegible]
  Pokegama Falls, Minn., operating and care of reservoir at 1,[illegible]
  Pokegama Falls, Minn., reservoir at 1,[illegible]
  Reservoir at head waters, examination of Mille Lacs Lake, Minn. 1,[illegible]
  Reservoirs at head waters, construction of 1,[illegible]
  Reservoirs at head waters, operating and care of 1,[illegible]
  St. Louis Harbor, Mo., improvement of 1,[illegible]
  St. Paul, Minn., construction of Lock and Dam No. 2 between Minneapolis and 1,[illegible]
  St. Paul, Minn., gauging at or near 1,[illegible]
  Skunk River to Fort Madison, Iowa, survey from 1,[illegible]
  Snag boats and dredge boats on upper river, operation of 1,23, 31[illegible]
  Snags and wrecks, removal of 1,2[illegible]
  South Pass, inspection of improvement of 1,25[illegible]
  Vicksburg Harbor, Miss., improvement of 1,5[illegible]
  Vicksburg Harbor, Miss., obstruction of mouth by small craft [illegible]
  V[illegible] Harbor, La., improvement by Mississippi River Commission 1,525; [illegible]
  Wrecks and snags, removal of 1,23, 317; [illegible]
Mississippi River Commission 1,525; [illegible]

.ssippi Sound, Ala. and Miss.:
)efenses of .... I, 7, 18, 721
Examinations for channel from Gulf of Mexico to Gulfport, via Ship Island Pass and Harbor, Miss .... I, 276; II, 1708
Survey of Horn Island Pass and Harbor, Miss .... I, 276; II, 1716
Survey of Ship Island Harbor for channel to mainland of Mississippi .... I, 277; II, 1722
ouri, Department of the, reconnaissances and explorations in.... I, 547; VI, 4131
ouri River:
Bridge at Boonville, Mo., construction of.................................. I, 529
Bridge at Yankton, S. Dak., construction of .... I, 529
.mprovement of, between Stubbs Ferry, Mont., and Sioux City, Iowa .... I, 333; III, 2177
.mprovement, surveys, etc., below Sioux City, Iowa............. I, 527; VI, 3837
Snagging on upper river.. I, 337; III, 2208
ouri River Commission.. I, 527; VI, 3837
(barge), removal of wreck of.. I, 138, 1157
ile and Ohio Railroad Company, bridges of.................................... I, 530
ile Harbor, Ala.:
Defenses of .... I, 7, 18, 721
.mprovement of .... I, 263; II, 1662
awk River, N. Y., examination of, between Rome and Schuyler... I, 482; IV, 3304
elumne River, Cal., improvement of................................. I, 489; IV, 3359
ey Point, Southern Branch, Elizabeth River, Va., removal of wreck off .... I, 198; II, 1380
mouth County, N. J., bridge of.. I, 532
ongahela Navigation Company, acquisition of improvements of. I, 361; III, 2411
ongahela River, W. Va. and Pa.:
Bridge at Rankin, Pa., construction of....................................... I, 533
Bridge between Braddock and Mifflin townships, Pa., construction of... I, 530
Bridge between Port Perry and Mifflin Township, Pa., construction of.. I, 529
Improvement of.. I, 359; III, 2383
Locks and Dams Nos. 6 and 7, acquisition of .... I, 361; III, 2411
Locks and Dams Nos. 8 and 9, operating and care of............. I, 360; III, 2409
Monongahela Navigation Company's improvements, acquisition of I, 361; III, 2411
roe, La., construction of bridge across Ouachita River by city of....... I, 530
roe, Fort, Va., sewerage system at .... I, 16, 663
roe Harbor, Mich.:
Examination of Raisin River.. I, 463; IV, 3094
Improvement of.. I, 452; IV, 3037
Water levels... I, 547; VI, 4127, 4128
tgomery, Ala., construction of bridge across Alabama River near....... I, 530
tgomery, Fort, N. Y., preservation and repair of .... I, 744
tgomery, Tuscaloosa and Memphis Railway Company, bridge of........ I, 530
ument River, Mass., construction of bridge across, at Bourne........... I, 534
sabec Bar, Me., improvement of .... I, 27, 771
gan Cut and Canal, Tex.:
Improvement of.. I, 294; II, 1803
Operating and care of Morgan Canal .... I, 298; II, 1808
ris and Cummings Ship Channel, Tex., construction of bridge across... I, 530
tars. *See* Fortifications.
nt Desert, Me., construction of breakwater to Porcupine Island .... I, 28, 775
nt Hope Bay, Mass., survey of .... I, 81, 931
.nt Pleasant shore, Charleston Harbor, S. C., improvement at..... I, 222; II, 1471
l Lake, La., improvement of .... I, 285; II, 1767
derkill River, Del., improvement of .... I, 160; II, 1266
cle Shoals Canal, Tennessee River, Ala., operating and care of... I, 351; III, 2296
kegon Harbor, Mich., improvement of .... I, 428; IV, 2923
kingum River, Ohio:
Improvement of.. I, 358; III, 2363
Observations concerning form of water surface backed up by dams in running streams .... III, 2378
Operating and care of locks and dams on.......................... I, 358; III, 2364
tic River, Conn., improvement of.. I, 84, 944
tic River, Mass., improvement of... I, 53, 841

N.

dua Creek, Va., improvement of...................................... I, 195; II, 1373
semond River, Va., improvement of.................................. I, 192; II, 1367

- Nanticoke River, Del. and Md., improvement of .... I, 15
- Nantucket, Mass., construction of harbor of refuge at........
- Napa River, Cal.:
  - Examination of .... I, 4
  - Improvement of........ I, 4
  - Survey of Mare Island Strait........ I, 4
- Narraganset Bay, R. I.:
  - Defenses of........
  - Examination for channel through Conanicut Island........
  - Improvement of........
- Narraguagus Bay, Me., removal of wreck at Millbridge........
- Narraguagus River, Me., improvement of........
- Natalbany River, La., improvement of........ I,
- Natchez Harbor, Miss., improvement of, by Mississippi River Commission .... I,
- Navigable waters:
  - Bridges across. *See* Bridges.
  - Compilation of laws for maintenance, etc., of........ I, 2
- Neches River, Tex.:
  - Bridge at Beaumont, construction of........
  - Improvement of........ I, 2
- Negro Cut, Indian River Inlet, Fla. *See* Indian River.
- Neosho River, Kans., examination of .... I, 3
- Neponset River, Mass., survey of........
- Nestugga River, Oreg., improvement of........ I,
- Neuse River, N. C.:
  - Improvement of........ I, 2
  - Improvement of waterway via........ I,
  - Survey of, at and below Newbern........ I, 2
- New Bedford Harbor, Mass.:
  - Bridges across Acushnet River to Fairhaven, construction of ....
  - Defenses at .... I, 7
  - Improvement of........ I
  - Survey of channel leading to proposed new draw in bridge to Fairhaven. I
- Newbern, N. C.:
  - Improvement of Neuse River at........ I, 2
  - Improvement of waterway to Beaufort, N. C........ I, 2
  - Survey of Neuse River at and below........ I, 2
- *New Brunswick* (ferryboat), removal of wreck of........ I,
- Newburyport Harbor, Mass., improvement of........ I
- New Hampshire, defenses of coast of........ I, 7
- New Haven Harbor, Conn.:
  - Construction of breakwaters in........
  - Construction of city bridge across Mill River........
  - Improvement of........ I
  - Survey of........ I,
- New Jersey, improvement of channel between Staten Island, N. Y., and. I, 1
- New Madrid Harbor, Mo., improvement of, by Mississippi River Commission .... I, 525;
- New Orleans Harbor, La.:
  - Defenses of .... I, 7
  - Improvement of, by Mississippi River Commission........ I, 525;
- Newport Harbor, R. I., improvement of........ I, 7
- Newport News, Va., removal of wreck in Hampton Roads, off........ I, 19
- Newport River, N. C. *See* Beaufort Harbor.
- New River, N. C.:
  - Improvement of........ I, 206; II,
  - Improvement of waterway to Beaufort Harbor, N. C........ I, 205; II,
- New River, Va. and W. Va., improvement of........ I, 379; III,
- New Shoreham, R. I. *See* Block Island.
- Newtown Creek, N. Y.:
  - Bridge at Long Island City, alteration of........
  - Examination of channel connecting Flushing Bay and........ I, 13
  - Improvement of........ I, 1
- New York Bay, N. Y. *See* New York Harbor.
- New York Harbor, N. Y.:
  - Battery, survey of channel between Governors Island and........ I, 14
  - Bay Ridge Channel and triangular area to Red Hook Channel, improvement of........ I, 1
  - Bay Ridge Channel and triangular area to Red Hook Channel, survey of........ I, 1

ork Harbor, N. Y.—Continued.
ttermilk Channel, improvement of........................ I, 125, 1117
ttermilk Channel, survey of........................ I, 140, 1177
ney Island Channel, examination of........................ I, 115, 1048
ney Island Creek, construction of bridge at Brooklyn........................ I, 534
ney Island Creek, examination of........................ I, 115, 1050
efenses of........................ I, 7, 13, 14, 610, 614
ast River and Hell Gate, improvement of........................ I, 111, 1026
ast River, construction of bridge across, by city........................ I, 532
ast River, establishment of harbor lines........................ I, 23, 1081
llis Island, modification of harbor lines at........................ I, 23, 1075
lushing Bay, examination of channel to Newtown Creek........................ I, 139, 1159
lushing Bay, improvement of........................ I, 123, 1106
ort Hamilton, removal of wreck below........................ I, 114, 1039
edney Channel, improvement of........................ I, 113, 1031
edney Channel, removal of wreck in........................ I, 114, 1039
overnors Island, survey of channel between the Battery and........................ I, 141, 1182
owanus Bay channels, improvement of........................ I, 125, 1117
owanus Bay channels, survey of........................ I, 140, 1177
owanus Canal, improvement of........................ I, 125, 1118
owanus Canal, removal of wreck in........................ I, 138, 1158
owanus Creek, survey of........................ I, 141, 1180
owanus Creek Channel, improvement of........................ I, 127, 1122
amilton, Fort, removal of wreck below........................ I, 114, 1039
arbor lines, establishment of........................ I, 23, 1067, 1070, 1075, 1077, 1081
arlem River, city bridge obstructing........................ I, 536
arlem River, improvement of........................ I, 110, 1019
arlem River, location and characteristics of bridges across........................ I, 1024
arlem River, modification of harbor lines in........................ I, 23, 1077
ell Gate, East River, improvement of........................ I, 111, 1026
udson River, modification of harbor lines in........................ I, 23, 1067, 1070
udson River, removal of wrecks in........................ I, 114, 1039, 1040
mprovement of........................ I, 113, 1031
Main ship channel, improvement of........................ I, 113, 1031
Narrows to the sea, survey from........................ I, 115, 1053
New Jersey, improvement of channel between Staten Island and .... I, 130, 1130
Newtown Creek, alteration of bridge across........................ I, 535
Newtown Creek, examination of channel to Flushing Bay........................ I, 139, 1159
Newtown Creek, improvement of........................ I, 128, 1125
Red Hook Channel and triangular area to Bay Ridge Channel, improvement of........................ I, 125, 1117
Red Hook Channel and triangular area to Bay Ridge Channel, survey of........................ I, 140, 1177
Schuyler Fort, sea wall........................ I, 611
Spuyten Duyvil Creek, characteristics of bridge at mouth of........................ I, 1024
Spuyten Duyvil Creek, improvement of........................ I, 110, 1019
Spuyten Duyvil Creek, modification of harbor lines........................ I, 23, 1077
Staten Island, improvement of channel between New Jersey and.... I, 130, 1130
Supervision of........................ I, 524; IV, 3499
Triangular area between Bay Ridge and Red Hook channels, improvement of........................ I, 125, 1117
Triangular area between Bay Ridge and Red Hook channels, survey of........................ I, 140, 1177
Wallabout Channel, examination of........................ I, 115, 1047
Wrecks, removal of........................ I, 114, 138, 1039, 1040, 1158
w York, New Haven and Hartford Railroad Company, bridge of........................ I, 533
w York, Philadelphia and Norfolk Railroad Company, bridge of........................ I, 533
w York State, defenses of lake ports in........................ I, 7, 20, 743
gara, Fort, N. Y., sea wall at........................ I, 20, 743
gara River, N. Y.:
  Improvement of Buffalo Harbor........................ I, 466; IV, 3107
  Improvement of, from Tonawanda to Port Day........................ I, 470; IV, 3123
  Improvement of Tonawanda Harbor and........................ I, 469; IV, 3116
ntic Harbor, Conn., survey of........................ I, 104, 972
mini Creek, Va., improvement of........................ I, 179; II, 1326
oksack River, Wash., improvement of........................ I, 511; IV, 3438
rfolk Harbor, Va.:
  Bridge across Southern Branch, Elizabeth River, construction of........................ I, 533
  Improvement of, and its approaches........................ I, 190; II, 1353
  Improvement of waterway to Albemarle Sound, N. C........................ I, 195; II, 1374
  Wreck off Money Point, removal of........................ I, 198; II, 1380

- North Branch, Chicago River, Ill. *See* Chicago.
- North Carolina, defenses of coast of ..... [illegible]
- North East (Cape Fear) River, N. C., improvement of ..... [illegible]
- Northern and Northwestern Lakes:
  - Defenses of ports in New York ..... [illegible]
  - Examination for ship canal to Hudson River ..... [illegible]
  - Improvement of channels in connecting waters of ..... [illegible]
  - Surveys, and correcting, printing, and issuing of charts ..... [illegible]
  - Water levels ..... [illegible]
- Northern New York Railroad Company, bridge of ..... [illegible]
- North Fork, Forked Deer River, Tenn.:
  - Improvement of ..... I, [illegible]
  - Survey of ..... [illegible]
- North Fork, Lewis River, Wash., examination of, to head of [illegible]tion ..... [illegible]
- North Hero Island, Lake Champlain, Vt., improvement of channel be[illegible] South Hero Island and ..... [illegible]
- North Landing River, Va. and N. C.:
  - Improvement of ..... [illegible]
  - Improvement of waterway via ..... [illegible]
- Northport Harbor, N. Y., examination of ..... [illegible]
- North River, N. Y. *See* Hudson River.
- North River, N. C., improvement of waterway via ..... [illegible]
- North River, Wash.:
  - Examination of ..... I, [illegible]
  - Improvement of ..... I, [illegible]
- Norton Shoal, Vineyard Sound, Mass., removal of wreck from ..... [illegible]
- Norwalk Harbor, Conn., improvement of ..... [illegible]
- Noxubee River, Miss., improvement of ..... [illegible]
- Nyack Harbor, N. Y., examination of ..... [illegible]

O.

- Oakland Harbor, Cal.:
  - Bridge to Alameda, alteration of ..... [illegible]
  - Improvement of ..... I, [illegible]
- Oak Orchard Harbor, N. Y., survey of ..... I, [illegible]
- Obion River, Tenn.:
  - Improvement of ..... I, 339, 341; [illegible]
  - Survey of ..... I, [illegible]
- Obstructions to navigation:
  - Action upon bridges constituting ..... [illegible]
  - Water hyacinth in Southern rivers ..... [illegible]
- Occoquan Creek, Va., improvement of ..... I, 17[illegible]
- Occupancy of structures built by the United States ..... I, 24, [illegible]
- Ocean County, N. J., bridge of ..... [illegible]
- Ocklawaha River, Fla., improvement of ..... I, [illegible]
- Ocmulgee River, Ga., improvement of ..... I, [illegible]
- Oconee River, Ga., improvement of ..... I, [illegible]
- Oconto Harbor, Wis., improvement of ..... I, [illegible]
- Ocracoke Inlet, N. C.:
  - Improvement of ..... I, [illegible]
  - Survey of ..... I, [illegible]
- Office of the Chief of Engineers ..... [illegible]
- Ogdensburg Harbor, N. Y., improvement of ..... I, 479; [illegible]
- Ohio River:
  - Dams Nos. 2, 3, 4, 5, and 6, construction of ..... I, [illegible]
  - Davis Island Dam, Pa., operating and care of ..... I, [illegible]
  - Falls of, including Indiana Chute, Louisville, Ky., improvement of I, [illegible]
  - Gauging ..... I, 23, [illegible]
  - Improvement of ..... I, [illegible]
  - Indiana Chute, improvement of ..... I, [illegible]
  - Louisville and Portland Canal, Ky., operating and care of ..... I, [illegible]
  - Marietta, Ohio, to mouth, examination from ..... I, [illegible]
  - Snag boat, operation of ..... I, 23, [illegible]
- Oldmans Creek, N. J., examination of ..... I, [illegible]
- Old Point Comfort Wharf, Va., removal of wreck in Hampton Roads near ..... I, [illegible]
- Olympia Harbor, Wash.:
  - Harbor lines at, modification of ..... I, 24; [illegible]
  - Improvement of ..... I, 512; [illegible]

o, Canada, commerce passing, in 1896........................ IV, 2999, 3004
o Lake:
 also Northern and Northwestern Lakes.
fenses on.. I, 7, 20, 743
ater levels.. I, 547; VI, 4127, 4129
agon Harbor, Mich., improvement of........................ I, 389; III, 2606
ting, care, and maintenance of certain pnblic works, provision for.... I, 23
e River, Fla., examination of.................................. I, 251; II, 1569
s, Mass., removal of wreck off Cape Cod, near........................ I, 63, 859
River, Mo.:
idge at Osceola, construction of.. I, 531
provement of, by Missouri River Commission................. I, 527; VI, 3837
la, Mo., construction of bridge across Osage River at................. I, 531
gatchie River, N. Y. *See* Ogdensburg Harbor.
go Canal, N. Y., widening locks of, to permit passage of war vessels.. I, 483; IV, 3324
go Harbor, N. Y.:
nprovement of... I, 476; IV, 3278
jury to structures at.. VI, 3986
ater levels.. I, 547; VI, 4127, 4129
Creek, Vt., improvement of.................................... I, 481; IV, 3299
Tail Lake and River, Minn., examination of, for reservoir..... I, 333; III, 2172
hita River, Ark. and La.:
ridge at Monroe, La., construction of.................................. I, 530
mprovement of... I, 302; III, 1904
ittle Harry (barge), removal of wreck of..................... I, 153; II, 1227
r Bay, N. Y.:
onstruction of bridge across Mill Neck Creek Inlet, by town of....... I, 533
xamination of harbor at.. I, 139, 1163
r River, N. H., examination of.. I, 43, 804

P.

o (scow), removal of wreck of.. I, 472
tine (schooner), removal of wreck of......................... I, 153; II, 1227
beach, Fla., survey at.. I, 252; II, 1585
ico River, N. C.:
mprovement of... I, 201; II, 1388
urvey of, at and below Washington .... I, 212; II, 1425
nkey River, Va., improvement of................................ I, 187; II, 1344
goula River, Miss.:
mprovement of... I, 269; II, 1692
urvey of, from mouth to Dog River, and up Dog River.......... I, 276; II, 1718
notank River, N. C., improvement of............................ I, 197; II, 1378
ic River, N. J., improvement of..................................... I, 129, 1128
a Loutre, Mississippi River, closing crevasse in.............. I, 291; II, 1776
psco River, Md.:
mprovement of channel to Curtis Bay............................ I, 173; II, 1306
mprovement of, including channel to Baltimore .... I, 172; II, 1299
mprovement of Spring Garden, Baltimore .... I, 174; II, 1307
urvey of Baltimore Harbor .... I, 174; II, 1308
Vreck off Fort McHenry, removal of............................. I, 174; II, 1307
hogue River, N. Y., improvement of.................................. I, 123, 1108
atuck River, R. I. and Conn., improvement of......................... I, 82, 940
ucket River, R. I., improvement of.................................... I, 73, 905
River, Miss.:
Bridge in Marion County, construction of .... I, 530
Carthage to Jackson, improvement from......................... I, 273; II, 1700
Edinburg to Carthage, improvement from........................ I, 274; II, 1702
ackson, improvement below...................................... I, 272; II, 1698
Survey of channel at mouth of.................................. I, 277; II, 1722
e Creek, Fla., improvement of .... I, 246; II, 1559
skill Harbor, N. Y., improvement of................................. I, 109, 1016
bscot River, Me.:
Defenses of .... I, 7, 11
Examination for removal of wreck in Marsh River, Frankfort.......... I, 43, 801
mprovement of... I, 30, 779
Survey of Bangor Harbor and... I, 44, 811
acola Harbor, Fla.:
Defenses of.. I, 7, 18, 714
Improvement of... I, 258; II, 1625

Pensaukee Harbor, Wis., improvement of [illegible]
Pentwater Harbor, Mich., improvement of [illegible]
Pequonnock River, Conn. *See* Bridgeport Harbor.
Pere Marquette Lake, Mich. *See* Ludington Harbor.
Petaluma Creek, Cal.:
  Examination of [illegible]
  Improvement of [illegible]
Petoskey Harbor, Mich., improvement of [illegible]
Philadelphia, Pa.:
  Construction of bridge across Schuylkill River, by city of
  Defenses of
  Improvement of Delaware River at [illegible]
  Improvement of Schuylkill River at [illegible]
Philipp, Miss., construction of bridge across Tallahatchie River at
Piers built by the United States, occupancy or injury of [illegible]
Pigeon bayous, La., improvement of [illegible]
Pike Creek, Wis. *See* Kenosha Harbor.
Pinebluff, Ark.:
  Improvement of Arkansas River at [illegible]
  Surveys of Arkansas River at [illegible]
Pine Island Harbor, Fla., examination of [illegible]
Pine River, Mich., improvement of [illegible]
Pine River, Minn.:
  Operating and care of reservoir at [illegible]
  Reservoir at [illegible]
Piscataqua River, Me., construction of bridge across, at Kittery
Pittsburg, Pa.:
  See also Ohio, Monongahela, and Allegheny rivers.
  Davis Island Dam, Ohio River, operating and care [illegible]
  Locks and dams in Allegheny River near, construction of [illegible]
Plaquemine, La., construction of bridge across Bayou Plaquemine at
Plaquemine Bayou, La.:
  Bridge at Plaquemine, construction of
  Improvement of [illegible]
Plymouth Harbor, Mass.:
  Examination of Gurnet Rock and other rocks at mouth of
  Improvement of
  Survey of
Pocomoke River, Md., improvement of [illegible]
Point Judith, R. I.:
  Construction of harbor of refuge at [illegible]
  Improvement of entrance to Point Judith Pond [illegible]
  Survey of easterly breakwater to shore [illegible]
Point Judith Pond, R. I., improvement of entrance to [illegible]
Point Pleasant, N. J., construction of bridge across Manasquan River at
Pokegama Falls, Mississippi River, Minn.:
  Operating and care of reservoir at [illegible]
  Reservoir at [illegible]
Ponchatoula River, La., improvement of [illegible]
Pontchartrain Lake, La., removal of wreck in [illegible]
Popes Island, New Bedford Harbor, Mass. *See* New Bedford Harbor.
Porcupine Island, Me., construction of breakwater to Mount Desert [illegible]
Portage Lake and River, Houghton County, Mich., improvement and operating and care of canal via [illegible]
Portage Lake, Manistee County, Mich., improvement of harbor of refuge at [illegible]
Portage River, Ohio. *See* Port Clinton Harbor.
Port Chester Harbor, N. Y., improvement of [illegible]
Port Clinton Harbor, Ohio, improvement of [illegible]
Port Huron, Mich.:
  Construction of bridge across Black River by city of
  Improvement of Black River at [illegible]
Port Jefferson Harbor, N. Y., improvement of [illegible]
Portland, Fla., construction of bridge across Alequa Creek near
Portland, Me.:
  Alteration of city bridge across Back Cove
  Defenses at [illegible]
  Improvement of harbor at, including Back Cove [illegible]
Portland, Oreg.:
  Improvement of Willamette River above [illegible]
  Improvement of Willamette River below [illegible]

d Channel (Canal), Alaska, survey of.......... I, 524; IV, 3487
rford Harbor, Oreg., improvement of.......... I, 494; IV, 3379
rry, Pa., construction of bridge across Monongahela River at.......... I, 529
outh, N. H., defenses at.......... I, 7, 11, 597
outh, Kittery and York Street Railway Company, bridges of.......... I, 534
obacco River, Md. *See* Chapel Point Harbor.
ashington Harbor, Wis., improvement of.......... I, 401; IV, 2687
ng Harbor, Wis., examination of.......... I, 393; III, 2643
si Creek, N. C., examination of.......... I, 199; II, 1383
ac River:
ueduct Bridge at Washington, D. C., repair of.......... I, 536; VI, 3987
eat Falls Dam, raising height of.......... I, 540; VI, 4018
provement of, at Washington, D. C.......... I, 175; II, 1313
authorized occupancy of Potomac Flats.......... VI, 3981
River, Mass., improvement of.......... I, 47, 829
e Ile Point, Marquette Bay, Mich., construction of harbor of refuge.......... I, 391; III, 2638
e Isle Bay and Peninsula, Erie Harbor, Pa. *See* Erie Harbor.
lence River, R. I.:
provement of.......... I, 74, 908
moval of Green Jacket Shoal.......... I, 75, 911
cetown Harbor, Mass.:
provement of.......... I, 62, 856
rvey of.......... I, 66, 878
buildings and grounds, District of Columbia, improvement and care.......... I, 542; VI, 4025
works:
ecessity of legislation for relief of injured employees engaged on.......... I, 25
ccupancy and injury of.......... I, 24, 536; VI, 3981
rovision for operating, care, and maintenance of certain.......... I, 23
Sound, Wash.:
efenses of.......... I, 7, 21, 763
nprovement of, and tributaries.......... I, 511; IV, 3438
nprovement of waterway to lakes Union and Washington.......... I, 513; IV, 3445
eyville Harbor, N. Y., improvement of.......... I, 474; IV, 3272
Rasa, Fla., examination of inside passage to Charlotte Harbor. I, 252; II, 1572

Q.

Anne's Railroad Company, bridge of.......... I, 532
s County, N. Y., bridge of.......... I, 535
stown Harbor, Md., improvement of.......... I, 169; II, 1286
ipiac River, Conn. *See* New Haven Harbor.

R.

e Harbor, Wis.:
mprovement of.......... I, 404; IV, 2698
urvey of.......... I, 409; IV, 2768
ay River, N. J., survey of, up to Rahway.......... I, 142, 1187
n River, Mich.:
xamination of.......... I, 463; IV, 3094
mprovement of Monroe Harbor.......... I, 452; IV, 3037
ocas River, N. J., improvement of.......... I, 150; II, 1219
in, Pa., construction of bridge across Monongahela River at.......... I, 533
ahannock River, Va., improvement of.......... I, 181; II, 1331
tan Bay, N. J.:
mprovement of.......... I, 133, 1142
Removal of wreck in.......... I, 138, 1157
tan River, N. J.:
improvement of.......... I, 132, 1136
Removal of wreck in.......... I, 138, 1157
nnaissances and explorations in military departments.......... I, 547; VI, 4131
Bank, N. J., site for defenses at.......... I, 639
Hook Channel and triangular area to Bay Ridge Channel, New York Harbor, N. Y.:
Improvement of.......... I, 125, 1117
Survey of.......... I, 140, 1177
Lake and Red Lake River, Minn.:
Examination of, for reservoir.......... I, 333; III, 2173
Improvement of.......... I, 330; III, 2159

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] improvement of
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] improvement of
[illegible]
[illegible]
[illegible]

[illegible]

[illegible] of
[illegible] improvement of [illegible]
[illegible] improvement of
[illegible] improvement of [illegible]
[illegible] improvement of
[illegible]
[illegible] construction of
[illegible] of
[illegible]
[illegible]
[illegible] improvement of
[illegible] improvements of
[illegible]
improvement of
[illegible] of
[illegible] of
[illegible] improvement of
[illegible] of
[illegible] construction of [illegible]
[illegible]
improvement of [illegible]
[illegible]
[illegible]
[illegible]
improvement of
improvement of [illegible]
[illegible] examination of

seph Harbor, Mich.:
nprovement of .... I, 423; IV, 2905
emoval of wreck in .... I, 434; IV, 2947
seph River, Mich.:
ridge in Berrien County, construction of .... I, 533
nprovement of .... I, 424; IV, 2909
nprovement of St. Joseph Harbor .... I, 423; IV, 2905
reck in St. Joseph Harbor, removal of .... I, 434; IV, 2947
seph Valley Railway Company, bridge of .... I, 533
wrence River, N. Y.:
ridge near Hogansburg, construction of .... I, 531
nprovement of .... I, 478; IV, 3290
nprovement of Cape Vincent Harbor .... I, 477; IV, 3286
nprovement of Ogdensburg Harbor .... I, 479; IV, 3292
ouis, Mo., improvement of Mississippi River at .... I, 320; III, 2046
ouis Bay, Minn. and Wis., improvement of, at Duluth, Minn., and Superior, Wis .... I, 386; III, 2592
ouis River, Minn. and Wis.:
ridge between Duluth, Minn., and Superior, Wis., construction of .... I, 533
mprovement of, at Duluth, Minn., and Superior, Wis .... I, 386; III, 2592
artin Parish, La.:
onstruction of bridge across Bayou Teche by J. B. Levert .... I, 534
onstruction of bridge across Bayou Teche at St. Martinville by ...... I, 534
artinville, La., construction of bridge across Bayou Teche at .... I, 534
arys Falls Canal, Mich.:
ommerce passing, during 1896 .... IV, 2999, 3004
amage to Fort Brady Pier .... VI, 3985
perating and care of .... I, 438; IV, 2997
arys River, Mich.:
ommerce passing St. Marys Falls Canal in 1896 .... IV, 2999, 3004
amage to pier at Sault Ste. Marie .... VI, 3985
mprovement of, at the falls .... I, 437; IV, 2963
mprovement of Hay Lake Channel .... I, 439; IV, 3006
perating and care of St. Marys Falls Canal .... I, 438; IV, 2997
esurvey of .... I, 545; VI, 4070
Vater levels at Sault Ste. Marie .... I, 547; VI, 4127
Vreck, removal of .... I, 451; IV, 3033
aul, Minn., gauging Mississippi River at or near .... I, 332; III, 2164
nnet Point, R. I., survey of .... I, 81, 934
nnet River, R. I.:
mprovement of .... I, 72, 904
urvey of Sakonnet Point .... I, 81, 934
n, Mass., bridge to Beverly, construction of .... I, 532
n River, N. J., examination of, up to Salem City .... I, 155; II, 1245
on Bay, Wash., improvement of waterway via .... I, 513; IV, 3445
on Creek, N. Y. *See* Pultneyville Harbor.
Beach, Lake Huron, Mich.:
mprovement of harbor of refuge at .... I, 444; IV, 3015
Water levels .... I, 547; VI, 4127
Diego Harbor, Cal.:
Defenses of .... I, 7, 20, 745
Improvement of .... I, 487; IV, 3337
lusky Harbor, Ohio, improvement of .... I, 454; IV, 3052
ly Bay, Cape Ann, Mass., construction of harbor of refuge at .... I, 49, 832
ly Hook, N. J., defenses at .... I, 7, 14, 618
ly Lake, Minn.:
Operating and care of reservoir at .... I, 328; III, 2142
Reservoir at .... I, 326; III, 2137
Francisco, Cal., defenses of .... I, 7, 20, 744, 748
Francisco Bay, Cal.:
Defenses of .... I, 7, 20, 714, 748
Improvement of Oakland Harbor .... I, 484; IV, 3327
Joaquin River, Cal.:
Improvement of .... I, 488; IV, 3357
Improvement of, and tributaries, by California Débris Commission .... I, 528; VI, 3961
Leandro Estuary, Oakland, Cal. *See* Oakland Harbor.
Luis Obispo Harbor, Cal., improvement of .... I, 485; IV, 3333
Pedro Bay, Cal. *See* Wilmington.
tee River, S. C., improvement of .... I, 219; II, 1458

Sarasota Bay, Fla., improvement of I
Sasanoa River, Me., improvement of ....
Sassafras River, Md., removal of wreck in Chesapeake Bay, abreast of
Saugatuck Harbor, Mich., improvement of I
Saugatuck River, Conn., improvement of, including Westport Harbor
Saugerties Harbor, N. Y., improvement of ....
Sauk River, Wis. *See* **Port Washington Harbor.**
Sault Ste. Marie, Mich.:
  Damage to Fort Brady Pier ....
  Water levels at I
***Saunders, Lizzie D.* (schooner), removal of wreck of** ....
Savannah Harbor, Ga.:
  Defenses at ....
  Improvement of, including channel to Beaufort, S. C ....
  Improvement of waterway to Fernandina, Fla ....
Savannah River, Ga.:
  Improvement of, above Augusta ....
  Improvement of, between Augusta and Savannah ....
  Improvement of channel between Savannah, Ga., and **S. C** ....
  Improvement of Savannah Harbor ....
  Improvement of waterway between Savannah, Ga., and Fer **Fla** ....
Sayville, N. Y., improvement of Browns Creek ....
Schuyler, Fort, N. Y., sea wall ....
Schuylkill River, Pa.:
  Bridge at Philadelphia, construction of ....
  Dike at Fort Mifflin, rebuilding of ....
  Improvement of ....
Scituate Harbor, Mass., improvement of ....
Seacoast defenses. *See* **Fortifications.**
Seaconnet Point, R. I. *See* **Sakonnet Point.**
Seaconnet River, R. I. *See* **Sakonnet River.**
Seattle and Rainier Beach Railway Company, bridge of ....
Sea walls ....
Sebewaing River, Mich., improvement of I
Secretary Creek, Md. *See* **Warwick River.**
Seekonk River, R. I. *See* **Pawtucket River.**
Severn River, Md. *See* **Annapolis Harbor.**
Shasta County, Cal., bridge of ....
Sheboygan Harbor, Wis.:
  Improvement of I
  Survey of I
Sheepshead Bay, N. Y., removal of wreck in I
Ship John Light, Delaware Bay, removal of wreck near ....
Ship Island Pass and Harbor, Miss.:
  Examinations for channel from Gulf of Mexico to Gulfport I
  Survey of Ship Island Harbor for channel to mainland of Mississippi I
Shoal Harbor, N. J., improvement of I
Shoalwater Bay, Wash. *See* **Willapa River and Harbor.**
Shrewsbury River, N. J., improvement of I
Sinepuxent Bay, Md., improvement of waterway via I
Siuslaw River, Oreg., improvement of mouth of I
Six Mile Island, Allegheny River, Pa., construction of lock and dam at. I
Skagit River, Wash., improvement of .... I, 511
Slack-water navigation. *See* **Canals.**
***Smith, Helen* (steamer), removal of wreck of** I
Smithtown Harbor, N. Y., examination of I
Smyrna River, Del., improvement of I
Snag boats, operation of:
  Ohio River .... I, 23, 35
  Upper Mississippi River .... I, 23, 32
Snake River, Wash., improvement of, up to Asotin .... I, 51
Snohomish River, Wash.:
  Improvement of .... I, 511
  Improvement of Everett Harbor .... I, 515
Snoqualmie River, Wash., improvement of .... I, 511
Snow Hill, Md., improvement of Pocomoke River below .... I, 10
South Atlantic States, obstruction of navigable waters in, by the water hyacinth ....

Carolina, defenses of coast of.......... I, 7, 16, 675
Chicago Harbor, Ill., improvement of.......... I, 412; IV, 2801
ern Branch, Elizabeth River, Va. *See* Elizabeth River.
ern Pacific Company, bridge of.......... I, 535
Fork, Forked Deer River, Tenn. *See* Forked Deer River.
Haven Harbor, Mich.:
nprovement of.......... I, 424; IV, 2910
urvey of.......... I, 434; IV, 2948
Hero Island, Lake Champlain, Vt., improvement of channel between North Hero Island and.......... I, 480; IV, 3299
Milwaukee, Wis., improvement of harbor at.......... I, 403; IV, 2696
Norwalk Harbor, Conn. *See* Norwalk Harbor.
Pass, Mississippi River, inspection of improvement of.......... I, 25, 277; II, 1731
port Harbor, Conn., survey of.......... I, 105, 986
River, N. J., improvement of.......... I, 133, 1139
hwest Baltimore, Md., improvement of harbor of (Spring Garden).. I, 174; II, 1307
gdale, Pa., construction of lock and dam in Allegheny River at.. I, 363; III, 2428
g Garden, Baltimore Harbor, Md., improvement of.......... I, 174; II, 1307
ten Duyvil Creek, N. Y.:
Bridge at mouth, characteristics of.......... I, 1024
Harbor lines at New York, modification of.......... I, 23, 1077
Improvement of.......... I, 110, 1019
n River, N. J. *See* Manasquan River.
e Harbor, Mass. *See* Chatham Harbor.
nford Harbor, Conn., improvement of.......... I, 100, 967
of the West (steamship), removal of wreck of.......... I, 308; III, 1932
en Island, N. Y.:
Defenses at.......... I, 7, 14, 613
Improvement of channel between New Jersey and.......... I, 130, 1130
laguamish River, Wash., improvement of.......... I, 511; IV, 3438
ne Bridge, Sakonnet River, R. I., increasing width and depth of draw opening in.......... I, 72, 904
nington, Conn., construction of harbor of refuge at.......... I, 83, 942
ictures built by the United States, occupancy or injury of.......... I, 24, 536; VI, 3981
rgeon Bay and Lake Michigan Canal, Wis.:
Construction of harbor of refuge at eastern entrance.......... I, 397; IV, 2671
Improvement of.......... I, 396; IV, 2660
Operating and care of.......... I, 397; IV, 2666
marine mines.......... I, 11
sun Creek, Cal., examination of.......... I, 488; IV, 3341
livan Falls, Sullivan River, Me., improvement of harbor at.......... I, 29, 776
llivan Island shore, Charleston Harbor, S. C., improvement at.......... I, 222; II, 1471
lphur River, La., Ark., and Tex. *See* Red River below Fulton, Ark.
matra (barge), removal of wreck of.......... I, 407; IV, 2751
perior Bay, Minn. and Wis.:
Harbor lines at Duluth, Minn., and Superior, Wis., modification of. I, 23; III, 2647
Improvement of, at Duluth, Minn., and Superior, Wis.......... I, 386; III, 2592
perior Harbor, Wis.:
Bridge across St. Louis River to Duluth, Minn., construction of.......... I, 533
Harbor lines at, modification of.......... I, 23; III, 2647
Improvement of.......... I, 386; III, 2592
perior Lake:
See also Northern and Northwestern Lakes.
Improvement and operating and care of waterway to Keweenaw Bay.......... I, 389, 390; III, 2608
Water levels.......... I, 547; VI, 4127, 4129
perior Rapid Transit Railway Company, bridge of.......... I, 533
pervision of New York Harbor, N. Y.......... I, 524; IV, 3499
rveys:
Compilation relative to examinations and.......... I, 24
Estimate for examinations, contingencies, and, of rivers and harbors.... I, 524
In military departments.......... I, 547; VI, 4131
squehanna River, Md., improvement of.......... I, 163; II, 1272
terville, Pa., construction of bridge across Youghiogheny River at.......... I, 533
wanee River, Fla., improvement of.......... I, 249; II, 1564
an Creek, Ohio, construction of bridge across, at Toledo.......... I, 531
an (schooner), examination for removal of wreck of.......... I, 43, 801
inomish Slough, Wash., improvement of.......... I, 516; IV, 3450
nepuxent Bay, Md. *See* Sinepuxent Bay.

T.

Tallahatchie River, Miss.:
Bridge at Philipp, construction of
Improvement of
Tampa, Fla.:
Examination of Hillsboro Bay and River up to
Removal of wreck in Hillsboro River at
Tampa Bay, Fla., survey of, from Port Tampa to mouth
Tappan Zee, N. Y. *See* Nyack Harbor.
Tar River, N. C., improvement of
Taunton River, Mass., improvement of
Tchefuncte River, La. *See* Chefuncte River.
Teche Bayou, La.:
Bridge at Jeanerette, construction of
Bridge in St. Martin Parish, construction of
Bridge at St. Martinville, construction of
Improvement of
Survey of, from St. Martinville to Port Barre
Tennessee River, Tenn., Ala., and Ky.:
Chattanooga, Tenn., improvement above
Chattanooga, Tenn., to Decatur, Ala.
Decatur to Florence, Ala.
Florence to foot of Bee Tree Shoals, Ala.
Gauging
Improvement of, and tributaries .... I, 34
Injury to training walls
Livingston Point, Ky., improvement at
Muscle Shoals Canal, Ala., operating and care of
Riverton, Ala., improvement below
Survey of mouth of
Tensas River, La., improvement of
Texarkana and Fort Smith Railway Company, bridge of
Thames River, Conn., improvement of
The Board of Engineers
The Dalles Rapids, Columbia River, Oreg. and Wash., construction of railway to Celilo Falls
Thimble Islands, Conn., removal of wreck at, east of Branford
Three Mile Rapids, Columbia River, Oreg. and Wash., improvement at
Thunder Bay River, Mich. *See* Alpena Harbor.
Tickfaw River, La., improvement of, and tributaries
Tillamook Bay and Bar, Oreg., improvement of
Toledo Harbor, Ohio:
Bridge across Swan Creek, construction of
Improvement of
Tombigbee River, Ala. and Miss., improvement of:
Columbus to Fulton, Miss
Demopolis, Ala., below
Demopolis, Ala., to Columbus, Miss
Fulton to Walkers Bridge, Miss
Tonawanda Harbor, N. Y., improvement of
Tongue Point, Columbia River, Oreg., removal of wreck below
Town Creek, Brunswick County, N. C., survey of
Town River, Mass., improvement of
Tradewater River, Ky.:
Examination of
Improvement of
Treadwater River, Ky. *See* Tradewater River.
Trent River, N. C., improvement of
Triangular area between Bay Ridge and Red Hook channels, New York Harbor, N. Y.:
Improvement of
Survey of
Trinity River, Tex.:
Bridge above Marianna, construction of
Improvement of
Tuckerton Creek, N. J., examination of, including flats at mouth
Tug Fork, Big Sandy River, W. Va. and Ky., improvement of
Tuscaloosa County, Ala., construction of bridge across Warrior River in
Twelve Mile Creek, Fla. *See* Orange River.

ve Mile Creek, N. Y. *See* Wilson Harbor.
Rivers Harbor, Wis., improvement of .... I, 399; IV, 2678

U.

qua River, Oreg., improvement of .... I, 498; IV, 3389
n Lake, Wash., improvement of waterway via .... I, 513; IV, 3445
n Railroad Company, bridge of .... I, 529
n River, Me.:
  Examination of, near Ellsworth .... I, 42, 800
  Improvement of .... I, 29, 777
n Street Railway Company, bridge of .... I, 535
ed States:
  Engineer School, Willets Point, N. Y .... I, 5, 22, 562
  Occupancy or injury of structures built by .... I, 24, 536; VI, 3981
na Creek, Va., improvement of .... I, 183; II, 1335
of structures built by the United States .... I, 24, 536; VI, 3981

V.

ey Creek, Ala., canal from Black Warrior River to Birmingham, via:
  Examination for .... I, 275; II, 1704
  Survey for .... I, 275; II, 1704
buren, Ark.:
  Improvement of Arkansas River at .... I, 311; III, 1952
  Survey of Arkansas River at .... I, 316; III, 1989
milion Bayou, La., improvement of channel, bay, and passes of .... I, 285; II, 1766
milion Harbor, Ohio, improvement of .... I, 456; IV, 3068
mont and Province Line Railroad Company, bridge of .... I, 535
ksburg Harbor, Miss.:
  Improvement of .... I, 306; III, 1927
  Obstruction of mouth, by small craft .... VI, 3982
alia Harbor, La., improvement of, by Mississippi River Commission .... I, 525; V, 3505
alhaven, Me., improvement of Carvers Harbor .... I, 34, 785
cennes, Ind.:
  Improvement of Wabash River above .... I, 367; III, 2453
  Improvement of Wabash River below .... I, 367; III, 2452
eyard Haven, Mass., improvement of harbor at .... I, 69, 892
eyard Sound, Mass., removal of wrecks in .... I, 80, 927, 928
usia Bar, St. Johns River, Fla., improvement of .... I, 240; II, 1550

W.

bash River, Ind. and Ill.:
  Improvement of .... I, 366; III, 2452
  Improvement of, above Vincennes, Ind .... I, 367; III, 2453
  Improvement of, below Vincennes, Ind .... I, 367; III, 2452
  Operating and care of lock and dam on .... I, 368; III, 2455
ccamaw River, N. C. and S. C., improvement of .... I, 213; II, 1439
ding River, N. J., examination of .... I, 154; II, 1238
kefield, Va., monument and wharf at .... I, 543; VI, 4061
llabout Channel, N. Y., examination of .... I, 115, 1047
lton County, Fla., bridge of .... I, 534
ppoo Cut, S. C., improvement of .... I, 223; II, 1479
rrior River, Ala.:
  Bridge in Tuscaloosa County, construction of .... I, 530
  Canal to Birmingham, examination for .... I, 275; II, 1704
  Canal to Birmingham, survey for .... I, 275; II, 1704
  Improvement of, below Tuscaloosa .... I, 265; II, 1678
  Improvement of, between Tuscaloosa and Daniels Creek .... I, 264; II, 1667
  Operating and care of locks and dams above Tuscaloosa .... I, 265; II, 1675
arwick River, Md., improvement of .... I, 166; II, 1277
ashington, D. C.:
  Aqueduct Bridge across Potomac River, repair of .... I, 536; VI, 3987
  Defenses of .... I, 7, 15, 650
  Potomac River at, improvement of .... I, 175; II, 1313
  Potomac River Flats, unauthorized occupancy of .... VI, 3981
  Public buildings and grounds and Washington Monument. I, 542; VI, 4025, 4032
  Washington Aqueduct, increasing water supply of city of .... I, 540; VI, 4018
  Washington Aqueduct, maintenance and repair of .... I, 537; VI, 3991
  Washington Aqueduct, raising height of Great Falls Dam .... I, 540; VI, 4018
  Washington Monument, care and maintenance of .... I, 542; VI, 4032

Washington, N. C.:
  Improvement of harbor at.................................... I,
  Survey of Pamlico River at and below.......................... I,
Washington Aqueduct, District of Columbia. *See* Washington. D. C.
Washington Lake, Wash., improvement of waterway to Puget Sound. I,
Washington Monument, Washington, D. C., care and maintenance of. I,
Wateree River, S. C., improvement of.................................. I,
Water hyacinth, obstruction of navigable Southern rivers, by the.........
Water-level observations:
  See also Hydraulics.
  Columbia River, Oreg. and Wash.................................. I,
  Mississippi River and tributaries............................. I, 2
  Mississippi River at St. Paul, Minn............................. I,
  Northern and Northwestern Lakes.................................. I,
Waterways:
  See also Canals.
  Albemarle Sound, N. C., to Norfolk Harbor, Va...................... I,
  Beaufort Harbor, N. C., to Newbern, improvement of................ I,
  Beaufort Harbor, N. C., to New River, improvement of.............. I,
  Beaufort Harbor, S. C., to Savannah, Ga., improvement of......... I,
  Chincoteague Bay, Va., to Delaware Bay, Del., improvement of... I,
  Delaware Bay, Del., to Chincoteague Bay, Va., improvement of... I,
  Fernandina, Fla., to Savannah, Ga., improvement of.................. I,
  Keweenaw Bay to Lake Superior, Mich., improvement and operating
    care of.. I, 38
  Newbern to Beaufort, N. C., improvement of........................ I,
  New River to Beaufort, N. C., improvement of........................ I,
  Norfolk Harbor, Va., to Albemarle Sound, N. C., improvement of. I,
  Puget Sound to lakes Union and Washington, Wash., improvem
    of... I, 51
  Savannah, Ga., to Beaufort, S. C., improvement of.................. I,
  Savannah, Ga., to Fernandina, Fla., improvement of................. I,
  Superior Lake to Keweenaw Bay, Mich., improvement and operating
    care of.. I, 38
  Union Lake, Wash., improvement of waterway via.................... I, 51
  Washington Lake to Puget Sound, Wash., via Lake Union...... I, 51
Waukegan Harbor, Ill.:
  Harbor line at, establishment of................................. I, 2
  Improvement of... I, 4
West Braddock Bridge Company, bridge of.................................
Western Branch, Elizabeth River, Va., improvement of................. I, 1
West Galveston Bay, Tex., improvement of channel in................. I, 2
Westport Harbor, Conn., improvement of.................................. I
Weymouth Back River, Mass.:
  Improvement of...
  Survey of, from Hingham Bridge to Mann's wharf......................... I,
Weymouth Fore River, Mass., improvement of ....
White Lake Harbor, Mich., improvement of............................. I, 4
White River, Ark.:
  Gauging .... I, 23, 3
  Improvement of.. I, 31
  Survey of, from Batesville to Buffalo Shoals...................... I, 31
  Survey of Buffalo Fork.. I, 31
White River, Ind.:
  Improvement of.. I, 3
  Survey of... I, 37
Wickford Harbor, R. I., improvement of...................................
Wicomico River, Md., improvement of................................... I, 1
Willamette River, Oreg.:
  Improvement of, above Portland...................................... I, 5
  Improvement of, below Portland .... I, 5
Willapa River and Harbor, Wash., improvement of .... I, 5
Willets Point, N. Y.:
  Battalion of Engineers.. I,
  Engineer Depot... I,
  Engineer School .... I,
  Estimates..
  Post of.. I, 4
Wilmington, Cal., improvement of harbor at.......................... I, 4

ington, Del.:
nprovement of harbor at .... I, 155; II, 1250
emoval of wrecks in harbor at.............................. I, 170; II, 1288
ington, N. C.:
efenses at .... I, 7, 16, 670
nprovement of Cape Fear River above.............................. I, 208; II, 1404
nprovement of Cape Fear River at and below.............................. I, 209; II, 1406
n Harbor, N. Y., improvement of .... I, 471; IV, 3126
ibigoshish Lake, Minn.:
perating and care of reservoir at .... I, 328; III, 2142
eservoir at .... I, 326; III, 2137
ah Bay, S. C., improvement of.............................. I, 217; II, 1452
lacoochee River, Fla., improvement of .... I, 219; II, 1564
Lake and River, Ill. and Ind., survey of.............................. I, 421; IV, 2887
bury Creek, N. J., rebuilding dike in Delaware River at.... I, 152, 639; II, 1223
s Hole Channel, Mass., improvement of .... I, 69, 894
ks, removal of.............................. I, 23
altimore Harbor, Md.............................. I, 174; II, 1307
ishop and Clerks Light, Vineyard Sound, Mass.............................. I, 80, 928
ranford, Conn .... I, 138, 1156
rooklyn, N. Y.............................. I, 138, 1158
ape Cod, near Orleans, Mass., off.............................. I, 63, 859
hatham, Mass.............................. I, 928
hesapeake Bay, Md.............................. I, 171; II, 1289
hicago River at Chicago, Ill.............................. I, 420; IV, 2881
hristiana River, Del.............................. I, 170; II, 1288
od, Cape, near Orleans, Mass., off.............................. I, 63, 859
olumbia River, Oreg .... I, 502; IV, 3406
arien Harbor, Ga.............................. I, 237; II, 1538
elaware Bay and River.............................. I, 153; II, 1227
dgewater, N. J.............................. I, 114, 1040
lizabeth River, Va.............................. I, 198; II, 1380
rie Harbor, Pa.............................. I, 472
ort Hamilton, New York Harbor, N. Y.............................. I, 114, 1039
ort McHenry, Baltimore Harbor, Md.............................. I, 174; II, 1307
rankfort, Me.............................. I, 43, 801
edney Channel, New York Harbor, N. Y.............................. I, 114, 1039
owanus Canal, New York Harbor, N. Y.............................. I, 138, 1158
reat Egg Harbor Inlet, N. J.............................. I, 153; II, 1227
amilton, Fort, New York Harbor, N. Y.............................. I, 114, 1039
ampton Roads, Va.............................. I, 198; II, 1379
enderson Harbor, N. Y.............................. I, 482; IV, 3304
illsboro River, Fla.............................. I, 251; II, 1566
udson River, at Jersey City and Edgewater, N. J.............................. I, 114, 1039, 1040
ersey City, N. J.............................. I, 114, 1039
ey West Harbor, Fla.............................. I, 251; II, 1566
eague Island, Delaware River, Pa.............................. I, 153; II, 1227
cHenry, Fort, Baltimore Harbor, Md.............................. I, 174; II, 1307
an of War Harbor, Key West, Fla.............................. I, 251; II, 1566
arsh River, at Frankfort, Me.............................. I, 43, 801
illbridge, Me.............................. I, 42, 798
ilwaukee Bay, Wis.............................. I, 407; IV, 2751
ississippi River.............................. I, 23, 317; III, 2001
oney Point, Elizabeth River, Va.............................. I, 198; II, 1380
arraguagus Bay, Me.............................. I, 42, 798
ewport News, Va.............................. I, 198; II, 1379
ew York Harbor, N. Y.............................. I, 114, 138, 1039, 1040, 1158
orfolk Harbor, Va.............................. I, 198; II, 1380
orton Shoal, Vineyard Sound, Mass.............................. I, 80, 927
ld Point Comfort Wharf, Va., near.............................. I, 198; II, 1379
rleans, Mass.............................. I, 63, 859
atapsco River, Md.............................. I, 174; II, 1307
enobscot River, Me., Marsh River branch of.............................. I, 43, 801
ontchartrain Lake, La.............................. I, 291; II, 1776
aritan Bay, N. J.............................. I, 138, 1157
aritan River, N. J.............................. I, 138, 1157
t. Joseph River at St. Joseph, Mich.............................. I, 434; IV, 2947
t. Marys River, Mich.............................. I, 451; IV, 3033
assafras River, Md., mouth of.............................. I, 171; II, 1289

[illegible]

Y.

[illegible] improvement of [illegible]

3 2044 103 133 344